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Putting the finishing touches on an elaborately decorated piece of china.

THE ROYAL PORCELAIN FACTORY AT BERLIN.—[See page 200.]

The Movements of the Moon—I*

A Popular Survey of Their Marvelous Multiplicity and Variations

By Percy Johnson

CERTAINLY, the moon is the most lovely orb of heaven, and richly deserves the title bestowed upon her by the poets—"Queen of the Night." There is no other heavenly body, with the possible, but doubtful, exception of the sun, which is subjected to more observation by "the man in the street," and there can be little doubt that this is chiefly due to her peculiar beauty as she presents her varying phases to our view, and to the pale soft loveliness of a moonlit landscape, which is more entrancing than the warmth and brilliance of one illumined by the glory and splendor of "King Sol" himself. Who has not beheld with pleasure the slender crescent of the young moon in the evening sky, or gazed in rapture on the heaving waters of the ocean glistening under the silvery moonbeams?

The sun may be the grandest, the most important object in the Universe so far as the inhabitants of the earth are concerned, in their dependence upon the beneficence of His Majesty's rays; the great nebula in Orion may be the most awe-inspiring spectacle astronomers have ever looked upon; Saturn, with its wonderful rings, may be the most unique revelation of the telescope; but—upon this, I think, all are agreed—the gentle loveliness of our faithful satellite, the moon, is unequaled in the realms above.

In which of her many changing aspects does the moon most delight the eye of man? Is she most lovely of all when seen in the beautiful western sky at sunset—an exquisite crescent with "the old moon in her arms"—or when serenely "sailing" high in the heavens, 'mid the fast flying clouds, she shines o'er land and sea, investing every scene with a beauty all her own, or is the great, golden harvest moon of autumn, rising night after night in the north-eastern sky about the time of sunset, the loveliest of all the lunar phases?

Who shall say?

In addition to this wealth of beauty, manifest to the most casual observer of Nature, the moon has many attractions which merit much attention, and which arise mainly from the fact that she is our nearest neighbor, and can be subjected to a closer scrutiny than can any of the other denizens of space.

To the amateur astronomer possessed of a telescope, the moon is certainly the most beautiful of celestial objects, and he can sit for hours at his instrument, reveling in the unsurpassed glories of the lunar landscape. To one who looks at the moon telescopically for the first time, the sight is a never-to-be-forgotten one. The jagged line of mountains, dividing day from night, catching the sunlight on their top-most peaks, looks like a row of snow-white crystals, or shining jewels, and never fails to draw forth exclamations of surprise and admiration. The strong contrasts of light and shadow are a never-ending source of delight and wonder—the shadows streaming across the plains, and revealing in exaggeration the contour of the mountain ranges.

The moon's interest, however, lies not only in her telescopic appearance, a description of which, unfortunately, cannot be included in the present article. With the single exception of the sun's apparent movement athwart the heavens, the moon's varying position among the stars, with the accompanying change in her phase of illumination, is the most obvious and striking of all astronomical phenomena, and one which has attracted the notice of man from times of the remotest antiquity. Although the earliest records extant in this connection are merely the expression of a primitive wonder and simple nature-worship, they are exceedingly interesting, and deserve more than the passing reference here made. They take the form of hieroglyphic inscriptions which the Egyptian races, of probably 6,000 years ago, left on their temple walls, showing us that the sun, moon and stars were then regarded with a seriousness we would do well, to a certain extent, to imitate. At that early period in the history of mankind, about which much might be written, the stage of thought was primarily that of worship, as is shown by the evidence of the deification of the various celestial bodies to be found on every hand in the majestic ruins of the vast and mighty buildings in that strange land on the banks of the Nile.

There is also ample evidence, however, that the utilitarian point of view was not neglected—indeed, it was more important than we are apt to realize in these days of calendars. This is conclusive in the case of the sun, whose variations were sedulously watched by the priests, both for religious and mundane purposes, and it is certain that the convenient division of time marked by successive lunations would direct an equally scientific attention to those of the moon. In one of the inscriptions referred to, the waxing moon is typified with that charming simplicity which always characterizes these pictorial writings, but which very simplicity often baffles the best brains for an explanation. It is known as "The Square Zodiac" of the chief temple of Denderah, and shows the moon-god at the top of a flight of fourteen steps, which symbolize both the moon's increasing phase, and the number of days between "new moon" and "full moon"! In another representation, the god is divided into fourteen pieces to illustrate the phenomenon of the waning moon!

In parenthesis, it may here be allowable to emphasize the better perspective of awe and wonder which obtained in those far off days, when even the succession of day after night was looked upon with feelings of doubtful confidence, than does with the majority of people to-day. Although it would be foolish to compare the vastly superior knowledge possessed by the public in general, and astronomers in particular, in the twentieth century, with that superstitious regard held by the ancients, it is, at the same time, that very excellence of the learning of to-day which is responsible for the careless indifference of the many to fundamental facts of nature.

These may not be of so recent discovery as, for example, the so-called "canals" on Mars, and may not be so sensational to the popular mind, but they are, nevertheless, among the most impressive things in the universe, fit food for the deepest thought and meditation.

All the heavenly bodies, sun, moon, planets and stars (and comets too, when they happen to be visible) daily perform an apparent revolution round the earth, due to the latter's diurnal rotation on its axis. The general ignorance which prevails respecting this motion of the stars is remarkable, but it will come as a shock to many readers when it is stated that many persons are entirely unacquainted with the moon's regular performance of this apparent daily motion. (The word "apparent" is used to signify that the movement is not real on the part of the moon, but is similar to the apparent motion of objects seen from the window of a traveling train.) The extent of their knowledge seems to be confined at the most to three weeks out of every month. What becomes of our satellite during the remainder of each period, remains with them as great a mystery as the Sphinx, and, it might be added, as far as they are concerned, matters less! Surprising as it may seem the writer has heard the greatest wonder expressed by otherwise intelligent persons at what should be the familiar sight of the moon in her first quarter in the afternoon sky. Such complete indifference to natural phenomena, whether "in heaven above . . . in the earth beneath, or in the waters under the earth," is not justifiable. It is our duty as intelligent creatures inhabiting this planet to take reasonable notice of what is taking place around us.

Let us, therefore, attach our interest to the common but beautiful spectacle of the crescent moon in the evening sky at sunset, watching night by night her progress among the twinkling stars, and try to realize something of the feeling which animated those who carved that simple note on the temple stone at Denderah, which will endure when this printed page, and the material bodies of those who read it, will have passed into oblivion.

In the first place, it is interesting to discover how soon the moon first becomes visible after the time given in calendars as that of "new moon." Previous to this, although the moon is in the immediate vicinity of the sun, she is lost in his superior luster, and we are apt to forget her presence until we are apprised of the fact by her withdrawal to a sufficient distance to permit her illuminated rim to be glimpsed. Theoretically, the completely dark "new moon" should be of brief duration, and quite a degree of enthusiasm may be introduced into monthly searches to secure earlier detection of the exceedingly delicate crescent she presents on her first appearance after emerging from the overwhelming brilliancy of the great luminary. Under the condition of such early observance, she will be disclosed in the evening by the diminution of the sun's powerful light, but, following the example of her grandparent, she sets almost immediately. Carried by the diurnal rotation of the heavens beneath our feet, she rises soon after the sun the next morning, and will doubtless be apparent in the sky throughout the day. It will be observed that the convex surface of the crescent is presented to that part of the sky in which the sun is situated. It is surprising how many artists spoil what otherwise might be good pictures by neglecting such an observation as this, and erroneously depicting the concave side turned toward the place of sunset, thus betraying their ignorance of the source of the borrowed radiance of the "Lamp of Night."

Once again the sun sinks in the golden west, and the shades of evening commence to fall. As twilight deepens into dusk, the moon, now appreciably advanced in phase, and occupying a position farther to the east than that of the previous evening, though sinking in the heavens, lingers yet awhile, an object of rare beauty and delight, hanging in the vault of heaven like some phosphorescent ball of liquid light set in a silver bowl.

"The old moon in the new moon's arms—"

so familiar! so charming!

It may be noted in passing that the bright crescent often seems to belong to a distinctly larger body than the remainder, which accentuates the appearance above referred to especially when the moon is "on her back," to use a popular expression.

This is an optical illusion, due to irradiation, by virtue of which, a light body projected on a dark ground appears to be larger than it is.

In the spring of the year, by reason of the oblique angle at which our satellite's path meets the horizon, the young moon remains in the sky, many hours after sunset; but eventually, whether sooner or later, as our hemisphere of this ponderous earth turns over for its night's repose, the horizon rises up and cuts her off from view, depriving us of her reflected rays, which, although so mild and gentle, have hidden the full glory and splendor of the starry firmament.

A similar sequence of events takes place during the next twenty-four hours, with the result that the moon is discovered still farther to the east, and more fully illuminated. When she happens to be near a star this motion, which is known to astronomers as "direct" motion because it is the moon's real movement as distinguished from that "apparent" daily rising and setting motion, is easily noticeable in the course of a couple of hours. The distance between the sun and moon is thus steadily increased by this persistent movement to the east, and the illuminated portion of the latter's disk is constantly directed to the former's. When about seven days old, the moon is in her "first quarter" and about the time of sunset is on the meridian—the line which passes through the zenith and the north and south points of the horizon. The gibbous phase is now entered upon, and every night the moon continues her journey to the east, until "full moon" is attained, when she rises at the time of sunset, and is on the meridian at midnight. Of course, when it is said that the moon is farther to the east, it must be understood that it is so at the time of our initial observation, which in this case was sunset, as the daily rising and setting motion due to the Earth's own rotation, carries it through all positions in the course of a day.

The phase now decreases, and it will be seen that the illuminated part has "faced about" and is now directed to the eastern sky. When she has reached her "last quarter" the moon does not rise till about midnight and at sunrise is on the meridian in the morning sky. During the next seven days she approaches closer and closer to the sun until a very fine crescent is attained, when she is seen only in the strong light of dawn in the east. Then she is lost in the sun's rays, to emerge shortly afterward as a brand "new moon" in the west!

This is the monthly cycle of the moon's changes, and although some may smile at such a labored description of what they think is of such common knowledge, the writer is content to let it stand in view of what was remarked in the early part of this article. Very little consideration of the above observations will convince one that the moon's light is not an inherent property, but that she is a dark, globular body reflecting the sun's rays, while the only explanation of the "backward" motion from west to east (which truly is "real" and "direct" motion), which has been distinguished from the daily movement from east to west (which truly is

*From *Popular Astronomy*.

only "apparent" and "retrograde"), is that the earth's satellite is revolving round its primary in a period of about four weeks.

According to Professor Newcomb both these facts have been known from the earliest times.

That her light should be so white need occasion no surprise when one thinks of the pure whiteness of the clouds, which at other times, when not reflecting the solar rays, are so dark and forbidding. It has been variously estimated, however, with regard to the intensity of the lunar beams, that from 300,000 to 600,000 "full" moons would be required to produce the degree of illumination experienced by the earth on a bright summer's day!

Let us now consider more closely the period taken by the moon to complete her orbital motion. Subsequently we shall deal with the dimensions of that orbit and certain variations in its form, which, though minute, are of great interest and importance, and were known thousands of years ago.

It has been mentioned that the interval of time between two successive "new" moons is about four weeks. Actually, the average period is 29½ days, but this does not represent the time taken to make a complete circuit of the earth. It is too great, for this reason: The sun, like the moon, has an independent movement apart from the daily rising and setting motion, which carries it from west to east. This is, however, not a "real" motion on the part of the sun, as was the moon's, but an apparent one due to the earth's yearly journey in space and consequent projection of the sun on every part of a great circular belt on the background of stars, known as the Zodiac. That is to say, the sun has a "backward" (direct) movement in the sky like the moon, but a much slower one, which only carries it through in a year what the moon can accomplish in a month. Therefore, when the moon arrives at that point in the great pathway of the stars at which she was last "new" she has circled the earth completely, but the sun has apparently moved farther to the east, and it takes the moon a little over two days to "catch up" and become "new" once more.

The first of these, the true period, because it may be referred to the position of the moon in the stars, which for this purpose may be regarded as forming a changeless background or dial, is termed the "sidereal" month. The second, or interval between two similar phases, is called the "synodical" month. The length of the sidereal month is 27 days, 7 hours, 43 minutes, 11½ seconds, while the synodic month is, as has been mentioned, 29½ days. There are, however, several minute variations which render this statement liable to slight modification, as will afterward appear.

The earth's annual motion round the sun, we have said, causes the latter to appear in various parts of the background of stars which is situated at an infinitely remote distance in comparison to those of both sun and moon. The constellations in which the sun successively appears (or indeed would do so if his light did not hide them) are the well known twelve signs of the Zodiac—Aries, Taurus, Gemini (the Ram, the Bull, the Heavenly Twins) etc., and its actual path which runs through this belt of the Zodiac is called the "Ecliptic." Its position is obviously determined by the direction of a line from the earth to the sun, and continued to the starry dial. As the earth proceeds on its annual voyage round the sun, this imaginary line will sweep round in a plane, which is "the Plane of the Ecliptic," or the plane of the earth's orbit. This plane is marked out then by the sun's path in the sky, which can be accurately marked down on a map of the stars.

Now the moon marks out its own track in the sky, and this can also be marked on the chart of stars. It is found on so doing that the moon's path cuts the sun's path or Ecliptic at an angle of five degrees.

Therefore, part of its monthly journey is above the plane in which earth and sun are situated, and the remainder is below that level. That point at which the moon commences to rise above the Ecliptic is called the "ascending node," and that at which it begins to descend below it, the "descending node." It is apparent that once a month when the moon is "new," it must occupy a position somewhere between the earth and the sun, and it is further quite clear that if she were *directly* between the two, or *in the Plane of the Ecliptic*, she would "eclipse," or interrupt the sun's light.

We have seen that the moon is in the plane of the earth's orbit at two points only, the nodes, so that when an eclipse occurs, it is certain that one of these nodes lies in a position exactly between the earth and the sun. If this node were fixed in that position, an eclipse would occur regularly every month at "new moon," but as eclipses are not of such regular occurrence, it follows that the moon, when occupying a position intermediate between the sun and earth, it is generally a little too high above the Plane of the Ecliptic, or a little too low down below it to be in an absolutely straight line between the two and cause an eclipse.

It is perfectly plain, therefore, that the position of the nodes is not constant; in fact, it has been found that these points are gradually changing their positions, and that in about 18½ years they make a complete revolution of the moon's orbit. A good idea of the effect of this on the plane of the moon's orbit can be obtained by spinning a plate on the ground. Just before it is about to collapse flat on the floor it will present a fair representation of what is taking place, each "wobble" corresponding to an 18½-year revolution of the nodes. Naturally the recurrence of eclipses of the sun and moon depends upon this phenomenon, as an eclipse of either of these bodies can only happen when the moon is at one of its nodes or a certain definite distance thereof, (1) at "new moon" and (2) at "full moon." Taking the case of solar eclipses: If no other circumstance had to be taken into account, an eclipse could happen only once in 9¼ years, or the time taken for a node to make half a revolution and occupy the position previously held by the other node. While this backward movement of the nodes, which amounts to 1 3/5 degrees a month, is taking place, however, the sun's position is moving forward (West to East) at the rate of 30 degrees a month, so that at the end of that time the node is removed from the sun's position 31 3/5 degrees, and in 5 3/5 months 180 degrees will separate the two positions. This means to say that the other node will now be in front of the sun, and the conditions for an eclipse again occur, so that two eclipses must occur within six months. We have assumed, however, that the node must be directly between the sun and the earth. This is not quite true, as the sun and moon are not mere points, but have a magnitude, so that if the node is sufficiently near to permit their respective disk edges to overlap a partial eclipse will be visible, while the magnitude of the earth allows an observer to move about to various vantage points and still further increase the frequency of eclipses of the sun. Indeed, eclipses of the sun are of more frequent occurrence than eclipses of the moon, *if the observer is always able to be on that part of the earth from which the solar eclipse is visible*, but if he is not able to move about in this way the lunar eclipses become the more common, for, while the belt of earth permitting observation of the former is narrow and is continually varying its position, the latter, when visible, is so from every part of a whole hemisphere of the earth. From what has been said it will be seen that, far from an eclipse happening only once in 9.3 years, a regular series of eclipses will be possible under the conditions laid down, but that after 18.6 years this series will start all over again, and the eclipses will all be repeated at successive intervals of time similar to those in the previous series.

The Chinese of two thousand years ago recorded eclipses, but not sysematically, whereas the Chaldeans were well acquainted with the period we have been discussing, which they termed the Saros, and were thus able to predict the recurrence of eclipses more or less truly.

(To be continued.)

Tarantism and the Dancing Mania

Some people, in an effort to explain the modern dancing craze, have attempted to liken it to the remarkable dancing mania of the Middle Ages. Whether this is true or not, it is interesting to recall to mind the extensive outbreak of frenzied dancing which swept over a great part of Europe, particularly during and immediately after the tremendous epidemics of the Black Death. One of the earliest outbreaks to be completely described occurred in Aix-La-Chapelle in 1374. The following strange spectacle was noted: Men and women "formed circles hand in hand, and, appearing to have lost control of their senses, continued dancing, regardless of the bystanders, for hours together in wild delirium, until at length they fell on the ground in a state of exhaustion. During the paroxysms the victims had hallucinations and some asserted that they felt that they had been immersed in a stream of blood, which obliged them to leap so high."

This extraordinary disease rapidly spread to many parts of Belgium, Holland and Germany, where it was variously known as St. John's or St. Vitus' dance, according to the saint who was supposed to protect those afflicted. The malady was first considered the work of the devil and the clergy were kept busy in their efforts to exorcise the evil one. That the disease was contagious was obvious and the victims were prone to acute recurrences.

In Italy, where the disease later appeared, the learned Nicholas Perotti, in an account of the disorder, points out that no one had the least doubt that it was caused by the bite of the tarantula, a common ground spider, particularly plentiful in Apulia, a southern district in Italy. It is significant to note this early attempt to explain the malady on natural lines and subordinate the supernatural. From the insect the disease was given the name of *tarantism*. There was a general conviction that by music and dancing the poison of the tarantula was distributed throughout the whole body, and expelled in the sweat induced by the great exercise. Later on it became evident that even those who were not bitten contracted the disease. Inquisitive persons who came to see the unfortunates in their wild dances not infrequently stayed to participate. Relief could only be obtained by dancing until complete exhaustion was produced. The musicians, who in some instances were employed by the municipality for this special purpose, were under no circumstances allowed to stop and substitutes had to be employed to relieve musicians who were themselves literally played out. As time went on it was noted that special kinds of music were very effective in bringing about the speediest cures. Music which permitted quick, lively dancing was most efficacious. A rapid music imported from Turkey soon became the standby and was given the name of tarantella, a term still used to describe a rapid whirling dance.

Tarantism was at its greatest height in Italy in the seventeenth century, long after the disease had disappeared in Germany. From this time the disease decreased but has appeared on occasions among special sects, as for example the Convulsionnaires in France, the Holy Jumpers and the Barkers in England, the Holy Rollers in the United States.

Space prohibits a discussion of the disease itself, suffice to say that it is definitely known to be a nervous disorder akin to imitative hysteria. It is doubtful if we shall ever see such widespread affections, but we may expect occasional outbursts of a similar character in connection with fervent revival services and the like. The poor physical and mental condition of the people in the past produced through poverty, plague and other disasters undoubtedly played no small part in preparing their minds for the disorder of the Dancing Mania.—*S. M. G. in Science Conspectus.*

A New Method of Repairing Injured Nerves

Dr. L. Edinger, a well-known neurologist of Frankfort, Germany, recently gave an address before the *Deutsche Orthopaedische Gesellschaft* on the subject of rebuilding torn and injured nerve tissue. According to Dr. Edinger, nearly all operations on nerves are at present attended by great uncertainty of result, and he ascribes this to a lack of knowledge of the theoretical relations governing nerve growth. Nerve fibers are semi-fluid structures proceeding from the ganglion cells, and in continuation of growth find new material in peripheral assistant cells. Dr. Edinger has been able to produce similar outgrowing structures from silicic acid. The nerve fiber remains throughout its existence dependent upon its original cells; so that when a nerve is divided, as by a shot wound, the portion cut off from the ganglion cell gradually perishes. Only the peripheral assistant cells referred to remain alive. But after such an injury there immediately proceeds from the ganglion cell a fresh putting forth of fiber through the central nerve-end, in an attempt to reach the separated ends. It can be proved that healing will always take place, even after the lapse of years, if these new fiber-ends do not meet with resistance in the blood or in the scar. But extending in every direction into the tissue they often do not conquer this resistance very quickly.

Other attempts which have been made to overcome this difficulty, such as sewing the nerves or transplanting nerves of other tissues between the two separated ends, have left much to be desired. Recently, however, according to the *Naturfissenschaftliche Umschau* (Cöthen), Dr. Edinger has devised an admirable method for promoting growth between the severed ends. He proceeds from the viewpoint that it is important above all to avoid resistance to the forth putting or processive action of the nerves.

Knowing that embryonal nerve-tissue will continue to grow in certain gelatins, even when separated from the parent animal, Dr. Edinger filled animal arteries with such gelatins, and after completely cutting away the scar, inserted the upper and lower ends of the human nerve into the artery filled with the gelatin. The hoped for result promptly ensued. With surprising rapidity the two ends of the separated nerve grew together. An admirable technique of operation has been elaborated by Dr. Ludloff, and it is believed that the new method will largely increase the percentage of recoveries from nerve injuries due to wounds.

A service truck equipped for telephone work.

A truck designed for construction work on trolley lines.

Modern Service Trucks

Important Equipment for Light, Power, Telephone and Electric Railway Companies

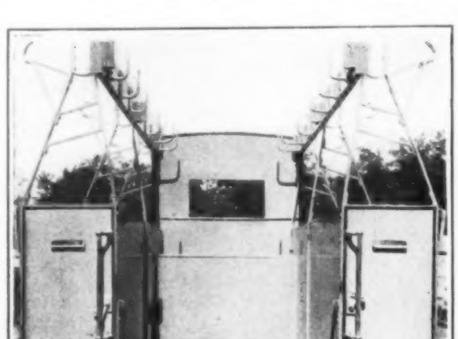
The public service companies that provide light and power, and the telephone and electric railway corporations could hardly do business without the motor truck, for, besides the construction work which they have under way most of the time, accidents are constantly occurring, and there are minor repairs and replacements required throughout a wide territory that must have prompt attention that can be given in no way as effectively as by the aid of a power vehicle that can convey men and material quickly to the necessary point. It is not surprising, therefore, that the motor truck has been so widely adopted by companies of this kind, as an indispensable adjunct to their emergency service.

As experience has been acquired in this class of work trucks of various sizes have been adopted as they have been found specially suited to the different needs, and special designs of body construction have been developed to meet the varied demands of the service and to facilitate the operations of the workmen. For the delivery of apparatus and supplies many telephone and lighting companies have adopted light ¾-ton vehicles, which have been found very useful for serving cities, and the same size has also been found well adapted for light construction and general maintenance work in suburban territory and in small towns. For maintenance and emergency work in the larger cities 1½ and 2-ton trucks are generally used; while for heavy construction work the larger companies have adopted vehicles having a capacity of 3 and 5 tons.

In designing the bodies of the trucks used for general repair work much ingenuity is disclosed, for a multitude of articles, both tools and materials, must be carried constantly, and to facilitate work these must be stowed so that anything desired can be quickly found. Two of the accompanying illustrations show views of a repair truck used by the Cleveland Telephone Company, and it will be seen that it is provided on both sides with racks for carrying ladders and poles, while there is a liberal number of hooks upon which ropes and coils of wire can be hung so that they can be got at conveniently. Bulky tools and supplies can be carried within the body of the vehicle, as well as a number of workmen; while the sides are formed of capacious lockers that are divided off into bins and compartments of various sizes for accommodating the smaller items of material and the extensive assortment of tools that must be ready to hand at short notice. The side racks also provide a support for a canvas cover, when it is needed, and the driver's seat has a permanent roof and sides, and there are curtains that enable it to be completely enclosed in bad weather. Besides the regulation lights there is a powerful searchlight so mounted that it can be directed at the top of a pole, down into a manhole or along a cable, not to speak of its use in finding the way along a country road of a dark night. This fitting has been found to be a very valuable adjunct for night work, for the telephone man has to answer an emergency call without regard to time or weather. The tailboard of the car is arranged to form a step for giving access to the interior.

The larger construction trucks are usually designed with a view to the special work they are intended for; thus, as will be seen in one of the illustrations, a derrick may be fitted for handling rails or other heavy material. Of course, this attachment is arranged to be operated, through suitable clutches, by the motor of the car. Practically all of these construction trucks are provided with power operated winches; and these winches are very useful for drawing cables into underground conduits. Overhead wires can also be readily hauled into position by such a winch, and both of these classes of work can be done much quicker by power than by any of the old hand methods.

Both repair and construction trucks are usually provided with draw bars that enable them to give a strong pull on a rope or tackle, or to assist a horse-drawn wagon. This draw-bar also makes it possible to attach a trailer for carrying additional material, thus greatly increasing the usefulness of the truck. Another idea is providing these trucks with a special bumper so they can assist another truck or wagon by pushing.



Rear view of a service truck, showing side racks for carrying ladders, poles and similar equipment.

The People's Gas Light & Coke Company of Chicago has a special-service truck that has proved of the greatest value, both to its owner and to the entire community, as its use has not only averted heavy property losses, but it has also been instrumental in saving many lives. The scope of service rendered by this truck is not limited to the property holdings of the company or to safeguarding the lives of its employees. It responds to every big fire alarm, gas leaks, sewer and street cave-ins, accidents to buildings, asphyxiation cases, suicides, drownings, leaking gas mains and meters and similar emergencies, rendering first aid to the injured and using the most modern type of pulmotor to revive unconscious victims.

The truck covers the entire city of Chicago, an area of over eighty square miles of territory. It can be summoned out at any hour of the day or night without expense to the city, corporation, contractor, physician or private individual.

In answering fire calls it is the duty of the attendants to rush into the burning building, turn off the gas or render every assistance to the injured or entrapped persons. Before the truck was purchased by the People's Company, firemen were greatly handicapped in discovering gas leaks or locating the shut-off valves. Delay of this kind was very dangerous and frequently gas explosions followed small fires that otherwise could have been averted had the fire fighters been able to quickly shut off the gas. The emergency men know the exact location of all gas lines, electric light connections, etc., and are able to render quick assistance.

In many instances special-service trucks, such as are mentioned above, have paid for themselves within a comparatively short time, and with further development, which will undoubtedly take place, many new ways will be found in which the power truck can be made useful.

Stimulating Germination in Old Seeds

An interesting report has just been made to the French Academy of Sciences regarding the power possessed by hydrogen peroxide of rousing the germinative faculty in seeds apparently too old to sprout. The investigator, Mr. Demoussy, as reported in the official organ of the academy, the *Comptes Rendus* (Paris) of March 13, took for the subject of experiment some watercress seed seven years' old. These seeds, when placed, but not immersed, in distilled water at 27 deg. Cent. (80 deg. Fahr.), a very favorable temperature for the development of good seed of this species, failed to germinate, but in diluted hydrogen peroxide in a 60 per cent solution, germination commenced on the third day, and after 10 days 30 per cent of the seeds had begun to sprout. When the solution was still more diluted the result was still better; with a 25 per cent solution the germinative faculty was exhibited in nearly 40 per cent of the seeds.

"A previous sojourn of the seeds in the peroxide solution, even quite prolonged, did not suffice; the germination takes place only in the actual presence of the reagent, and since the latter is rapidly decomposed in the presence of the seeds, to such a degree as to lose nine tenths of its active oxygen within 24 hours, it should be renewed daily."

The experimenter then asked himself how the oxygenated water produced this effect of arousing the dormant vitality of the grain. There were two possibilities: it

might act as an antiseptic to destroy injurious parasitic germs which would otherwise injure the budding sprout, or its action might result from its being a source of oxygen. Mr. Demoussy made some painstaking experiments to settle these points.

"When the old seeds were placed in pure water at 27 deg. Cent. (80 deg. Fahr.) they were quickly invaded by microbes, whose development, which at this temperature is very rapid, commences on the second or third day. Nothing of the sort takes place in the oxygenated water. However, soaking in an antiseptic solution does not have the same result. I found it impossible, for example, to sterilize the cress seeds by sublimate; a sojourn of an hour in a one thousandth solution was not sufficient to kill the parasitic germs imbedded in the mucilage of the integuments. They could be destroyed only by long contact with an antiseptic non-injurious to the seeds themselves, such as hydrogen peroxide."

Mr. Demoussy then repeated his experiments at other temperatures—attainable in the laboratory—varying from 10 deg. to 14 deg. Cent. (50-57 deg. Fahr.) and obtained different results. All the specimens commenced to germinate about the sixth day. At the end of 15 days 25 per cent, on the average, had sprouted in the pure water and 45 per cent in the 25 per cent solution of oxygenated water. This proved the curious fact that seeds which germinated in considerable proportion in the cold refused to germinate at 80 deg. Fahr., which is a highly favorable temperature for young seeds. At this temperature the latter will show sprouts 2 millimeters in length (about 0.08 inch) at the end of 24 hours, but at 12 deg. Cent. (53 deg. Fahr.) the sprouts are barely discernible.

The reason for this is that at the low temperature the microbian development is very slow, not manifesting itself till towards the tenth day, after the beginning of germination.

"This observation permits us to explain the preceding facts. In the old cress seeds the germinative energy is greatly diminished, so that it is not until after a relatively long time that development begins. These seeds of feeble vitality engage in a fight for oxygen with their parasites as rivals. The victory rests with one or the other, according to the various circumstances.

"At 27 deg. Cent. the microorganisms develop rapidly, in less than 48 hours, and there is no oxygen available for seeds which require 4 days to begin germination; hence, the seeds rot. But at the low temperature conditions are reversed; it is now the microbian development which is retarded for several days later than germination. When the seeds are placed in the oxygenated water this reagent opposes the evolution of the microbes, but not that of the seeds. . . . The resistance of the microorganisms to antiseptics, and the consequent facility with which they intercept, like a screen, the arrival of oxygen to the seed, is probably greatly favored in the case of the cress seeds, by the presence on their integument of the mucilage referred to above, which serves them as an excellent medium of culture.

"At the same time, the oxygenated water furnished a source of oxygen; this proceeds from its effect on the good cress seeds, from the latest harvest. When heated the lengthening of the sprouts is considerably increased by its presence to such a degree that one might say their development is a function of the increased supply of oxygen. In the cold, the processes of oxidation being less rapid, the oxygenated water ceases to be useful; slightly toxic, it may even retard the germination a little bit.

"A final demonstration may further show the exactitude of this interpretation. The same old seed which would not germinate in pure water at 27 deg. Cent. (80 deg. Fahr.) germinate in a proportion of 25 to 100 (25 per cent) when placed in damp sand; this is because the surface of aeration is more extensive and the arrival of oxygen is thus facilitated.

"To resume, old seeds may have consumed their germinative faculty and yet may fail to germinate in conditions known to be favorable to young seeds, if such conditions are still more favorable to the development of parasitic microorganisms capable of smothering them. Inversely the seeds will germinate if measures be taken which facilitate their oxidation, or which retard the development of these microorganisms."

A collorary drawn from these experiments by Mr. Demoussy is that many seeds which are rejected in the malthouses after a study of their germinative power would show a considerable percentage of ability to sprout when sown by the farmer, because the conditions of aeration and temperature would be more favorable. This inference has been tested in practice and found correct, particularly in the case of the sugar beet.

Diving Spectacles

Every swimmer and diver knows the difficulty of seeing under water with the unassisted eye. Objects presents vague and indefinite outlines. A piece of paper printed in heavy type is perceived only as a roundish white blot. The reason for this phenomenon lies in the curved shape of the cornea of the eye. This causes the water to surround the eye in the form of a diffraction

Glasses that can be used either in the air or water.

lens. In order to see under water as clearly as in air it is necessary, therefore, to counteract this tendency by inserting a suitable lens to correct the divergence of the rays of light.

This object can be accomplished by means of enclosed spectacles made of parallel planes of glass, so that the eye is surrounded by air, as it is within the helmet of a large diving apparatus. But the attachment of such spectacles to the face offers serious difficulties, and unfortunately these increase enormously as the water pressure increases.

A German firm have recently put on the market diving spectacles intended to remedy this difficulty. According to *Die Umschau*, to which we are indebted for the

Using an under-water telescope.

accompanying illustration, these can be used both in air and in water. Thus they are specially useful to divers descending in apparatus without a helmet. They utilize a plane-concave air lens. They are intended for wrecking divers, for sponge and pearl divers, for amateurs interested in deep-sea marvels, etc.

But they are also adapted to be employed by firemen when entering smoke-filled interiors. As shown in the illustration, the casing is provided with small valves. These are opened when the glasses are used for diving. Consequently, the space before the eyes is filled with water. But this space is filled with fresh water when the diver is going down in very dense salt water. The rubber cushions close comparatively air-tight, and on this account the spectacles can be used with closed valves when it is necessary to penetrate smoke-filled rooms. They are expected to be very useful at the present time to divers who descend to rescue wrecked submarines and flying machines. Obviously time-saving is an important item to all divers, and clear vision of the objects naturally reduces the time required.

Ancient Botany of the Zuni Indians

An interesting account of the ethnobotany, or early knowledge of botany, of the Zuni Indians, written by the late Mrs. Matilda Coxe Stevenson, who for many years studied Indian lore, especially that of the Pueblo tribes of New Mexico, was published recently in the 30th Annual of the Bureau of American Ethnology.

Under the medicinal uses of plants by the Zuni, Mrs. Stevenson says that medical treatment is older than intelligence in man: The dog hunts the fields for his special grass medicine; the bear dresses the wound of her cub or fellow-bear with perhaps as much intelligence as primitive man observes in his empirical practice. Primitive man does not know why his medicine cures; he simply knows that it does cure. He believes disease to be the result of malign influence, including that of his fellow man, to whom he attributes the power of sorcery which he himself is unable to overcome; hence, he must summon the aid of the beast gods, who alone possess the power of combating the malevolent practices of the sorcerer, while he administers their medicine. The plants of the gods cannot effect a cure, however, by the mere use of the medicines concocted from them; during the treatment of the patient prayers and supplications must be offered to the gods to whom the medicine belongs.

The therapeutics of these Indians is largely associated with occultism, these people having discovered through the ages and brought into practical use numerous valuable plant medicines, although in the first stages it was not understood that they were endowed with healing properties, except as they were associated with the gods, and the old conception still prevails.

That plants play an important part in the daily life of the Zuni is shown by Mrs. Stevenson, who found that in their belief plants verily form a part of themselves, being regarded as sentient beings; for the initiated of the Zuni could talk to them and the plants could answer. Plants were also held to be sacred, some of them having been dropped to the earth by the Star People; some were originally human beings, others the property of the gods, and all were the offspring of the Earth Mother. So interwoven with plant life, in both a religious and an economic way, are the customs and beliefs of the Zuni people, and so dependent are they on the products of the soil that their culture may be said to have had its origin in concepts pertaining to the vegetable kingdom.

Mrs. Stevenson found that plants used in medicine by these Indians were not employed entirely in a shamanistic way, experience having shown that many medicines derived from plants have real medicinal value. They are often properly and effectively prescribed by native doctors, although the medicinal practice of the Zuni has not passed beyond the empirical or experimental stage, notwithstanding their relative high degree of culture. The various uses to which plants, and their parts, are put by these Indians as food and medicine, in weaving, dyeing, basketry, decoration, toilet, folk-lore and ceremonies, as well as a source of names pertaining to clans, are described by the author.

Indian names designating plants were sometimes found to be the same for two or more kinds, but instead of this signifying a lack of specific knowledge on the part of the natives, this was found to be due to the fact that these plants served the same purposes or had similar characteristics, although unlike botanically. Plant names show a close association with animal names, and a number of them are supposed to belong to the animals for which they are named, a fact which accounts for an erroneous belief on the part of some students who have thought these particular medicines a part of, or made from, the animal.

Besides the plants held to be the property of the gods, others belong to medicine orders of secret fraternities or individuals, while some of their botanical remedies are the property of the general community. Antiseptics and narcotics were employed by the Indians, as well as other primitive peoples, at a very early date, although civilized man was much slower to adopt these now indispensable aids to medical science. It seems, however, that while narcotics were used in many operations, they were seldom given when bullets were being extracted, the Zuni saying that as men were not like women, they must of necessity *be men*, and accordingly the bullets were cut out without further ado.

Electrolytic Iron*

A Review of Recent Progress and Processes, and an Estimate of Cost of Production

By Oliver W. Storey, of the Burgess Laboratories

ELECTROLYTIC iron, up to within the past few months, has been a laboratory rather than a commercial product, but recent developments show that it is another electrochemical achievement to take its place among the industries of this country. At least one of the large electrical concerns is turning out 1,000 pounds (453 kilogrammes) of electrolytically refined iron per week with a probable increase to several times this output in the near future. The method used is that developed by Burgess[1] and later modified by Watts.[16] The electrolyte consists of 150 grammes of $FeSO_4.7H_2O$, 75 grammes $FeCl_2.4H_2O$, and 120 grammes $(NH_4)_2SO_4$ per liter, with a specific gravity of 1.125 at 20 deg. Cent. Ammonium oxalate is used as an addition agent. The anodes consist of bars of basic open-hearth steel. The deposit reaches a thickness of ⅜ to ½ inch (10 to 13 millimeters) before it is necessary to remove the cathode.

While the electrolytic refining of iron is an infant industry at the present time it is well to remember that electrolytic zinc refining was at the same stage of development a year ago. Two years ago it was thought doubtful whether the problem could be solved except in the distant future. Now we read in the technical press of the erection of electrolytic zinc refineries whose cost will amount to several millions of dollars. With this example before us who can predict what the next few years will accomplish in the electro-deposition of iron?

Electrolytic iron is known to have been produced on a laboratory scale seventy years ago. As long ago as 1860 it was used for the plating of copper engravings for the printing of bank notes at the Imperial Mint at Petrograd, Russia. Until recently the only use to which electrolytic iron had been put was in the so-called "steel facing" of dies and electrotypes. Its hardness, which makes it suitable for such purposes, is due to hydrogen, either occluded or combined.

The commercial production of electrolytic iron as a source of pure iron received a decided impetus in 1904 when Burgess and Hambuechen[1] presented their paper on "Electrolytic Iron" before this society. They showed that it was possible to refine iron by methods similar to those used for the refining of copper and obtain deposits up to one inch in thickness. The electrolyte consisted of a neutral ferrous sulphate solution containing some ammonium sulphate, while the anodes consisted of slabs of wrought or other soft iron. The current efficiency of deposition was near 100 per cent and the resulting iron was of a high degree of purity, containing less than 0.10 per cent and often under 0.03 per cent of impurities. Over three tons of iron was refined and used for the production of over 1,000 "pure iron" alloys which were tested for their various properties.

After several years' experience upon a semi-commercial scale at the University of Wisconsin, Burgess[4] gives the following figures on the cost of commercial refining of mild steel, the product being an iron of a high degree of purity. He estimates the power cost per ton at $10, with power at a cent per kilowatt hour, one kilowatt hour producing two pounds (907 grammes) of iron. The cost for labor, solution maintenance and fixed charges is estimated as equal to the power charge or $10. The anode material is assumed to be a mild steel costing $35. This would make the total cost about $55 per ton of refined iron. With power at ½ cent per kilowatt hour this cost would be reduced to $50.

In 1908 Cowper-Coles[2] described a method of making finished iron sheets and tubes by electrolytic methods from pig iron or from iron ore, using insoluble anodes when ore was used. The electrolyte was a 20 per cent solution of sulpho-cresylic acid saturated with iron. The method differs from the Burgess process in that pig iron and iron ore are refined, and in a different choice of electrolyte. The process has not been used commercially though works are being erected for the manufacture of electrolytic iron by this method.[3]

A detailed description of the Cowper-Coles process is given by Palmaer and Brinell.[4] They state that the electrolyte is a concentrated solution of ferrous chloride with additional organic compounds, such as the cresol-sulphonic acids, and enough iron oxide to make a sort of a gruel. The additional iron oxide is used for reducing the acidity and polishing the iron which is deposited as a sheet on a rapidly revolving cathode at a temperature near the boiling point of water. The current density used is about 63 amperes per square foot (7 amperes per sq. dm.). The resulting product is brittle, due to the presence of several tenths of one per cent of hydrogen. It also contains about 0.50 per cent of impurities, exclusive of hydrogen, while the pig iron used for anodes contains about 7 per cent. The chlorine content of the deposited iron is high, probably being occluded electrolyte. This is a serious defect as it impairs the mechanical properties and promotes rusting. The figures given by Palmaer and Brinell show that the cost of the electrolytic iron would be from 2½ to 3 cents per pound (453 grammes), depending upon the cost of power, though the inventor claims that the cost is below 2 cents.

In 1911 Fischer took out patents[6] for the manufacture of ductile electrolytic iron in which he claims that ductile iron may be deposited from a hot solution of ferrous chloride if hygroscopic salts, such as the chlorides of calcium, magnesium, or aluminium, are added to the electrolyte. He claims that the ductility of the product increases with the electrolyzing temperatures and that perfectly ductile iron is obtained at temperatures varying between 100 deg. and 120 deg. Cent. The preferred solution consists of a highly concentrated mixture of ferrous and calcium chlorides, 450 parts of ferrous chloride, and 500 parts of calcium chloride being dissolved in 700 parts of water. Under these conditions a current density of 180 amperes per square foot (20 amperes per sq. dm.) may be used.

Fischer's method for the production of ductile electrolytic iron is used by the Langbein-Pfanhauser-Werke of Germany for the commercial production of sheets and other articles. Duisberg[7] states that by this method the iron is deposited free of hydrogen and that its hardness sinks below that of silver and gold, and is not much greater than aluminium.

Ramage[8] took out a patent in 1911 in which he makes electrolytic iron from iron ore. The ferric ore is dissolved in sulphuric acid and reduced to the ferrous state by sulphur dioxide. The anode compartment of the electrolytic cell is separated from the cathode compartment by a diaphragm. The portion of the electrolyte in the anode compartment is kept saturated with the sulphur dioxide which acts as a depolarizer. The electrolyte in the cathode compartment must be kept free of sulphur dioxide as the nascent hydrogen at the cathode would reduce it, depositing sulphur and contaminating the iron.

Part of the sulphur dioxide is oxidized to sulphuric acid at the anode. Ramage proposes to concentrate this liquor and distill off the acid. In this manner the products are both sulphuric acid and electrolytic iron.

In a later patent Ramage[9] dissolves iron in a ferric liquor and electrolyzes the resulting ferrous liquor in a cell with a diaphragm and insoluble anode. The ferric liquor and free acids which result at the anode are again reduced and neutralized by the impure iron to be refined. This later operation is carried out in a separate tank and the resulting liquor filtered to keep the liquor clear in the refining tank.

In 1913 Boucher[10] received a patent in which the electrolyte is a solution of one or more ferrous salts, such as the sulphate or chloride. This is stirred in contact with the air before electrolysis to form iron-oxychloride which reacts with the hydrogen formed at the cathode and therefore acts as a depolarizer. The electrolyte is described as having a clear chestnut brown color and should not foam. During electrolysis, oxidation may be controlled by means of an adjustable opening in the cell cover. To reduce any ferric salts formed the electrolyte is passed over iron shavings in a separate vessel at a speed varying with the current density and with the amount of phosphorus in the cast iron anode. If this amount is 1 per cent, a circulation of 4 liters per hour per ampere is suitable. The concentration of the electrolyte is regulated in accordance with the amount of air supplied, but must be maintained constant during working; a suitable density is 35 deg. to 40 deg. Bé. The Cathode is rotated at a speed proportional to the current density; peripheral velocities of 100 to 120 meters per minute are suitable respectively for densities of 45 to 72 amperes per square foot (5 to 8 amperes per sq. dm.). The temperature of the electrolyte is raised for high current densities, but must not vary during electrolysis; it may be 50 deg. and 75 to 77 deg. Cent., respectively, for densities of 36 and 90 amperes per square foot (4 and 10 amperes per sq. dm.). Iron thus obtained is annealed and is then ready for commercial use.

Reed's patent[11] covers both the manufacture of electrolyte iron and the making of sulphuric acid as a by-product. The electrolyte is a solution of iron sulphate. The anode is made of spongy lead which becomes sulphated as the electrolysis proceeds. By this method free sulphuric acid does not form in the electrolyte and there is no tendency for the cathode to dissolve. The resulting lead sulphate is treated electrolytically in a separate receptacle and the sulphuric acid recovered. It is claimed that the electrolytic iron is free of hydrogen.

In 1913 Cowper-Coles[12] obtained a British patent in which he proposes to avoid exfoliation and brittleness in electro-deposited iron by suspending an iron sponge in an electrolyte used for refining iron. He claims to make iron tubes, ingots, sheets or produces pure iron directly from ores. The electrolyte is a concentrated solution of $FeSO_4$ or $FeCl_2$ which is electrolyzed, with or without a rotating cathode. As an example he states that a nearly boiling solution containing 1500 grammes $FeSo_4$ per liter is used as electrolyte and under such conditions the current density may be as high as 40 amperes per square foot (4.5 amperes per sq. dm.). The iron sponge may be gotten by roasting a sulphide or other iron ore, with recovery of the sulphur and then reducing by gas.

Guillet,[13] in a paper before the Iron and Steel Institute in 1914, described the process of the French Company "Le Fer" at Grenoble for making electrolytic iron. This company makes tubes, sheets, and material to be melted, the raw material being pig iron. A cathode revolving in a neutral solution of iron salts is used, the solution being maintained neutral by the circulation of the electrolyte over the surface of the iron. The bath also receives periodic additions of a depolarizing medium such as the oxide of iron. About 90 amperes per square foot (10 amperes per sq. dm.) is the current density used.

An iron having the following average analysis is claimed to be produced after removing the gases:

	Per Cent.
Carbon	0.004
Silicon	0.007
Sulphur	0.006
Phosphorus	0.008

Guillet states that it is possible to guarantee phosphorus lower than 0.010 per cent. When a current density of 90 amperes per square foot (10 amperes per sq. dm.) is used the yield per kilowatt year is two tons of metal, including cost of power for accessory service. The iron is annealed at 900 deg. Cent., after which it possesses a high degree of ductility and can be readily worked. The current density used would depend upon the cost of power. By using a current density of 45 amperes per square foot (5 amperes per sq. dm.) instead of 90, four tons of iron may be produced per kilowatt year instead of two as the voltage drops one half. Where the cost of power is high the current density should be low to secure higher efficiency. Guillet estimates that the total cost would be from $30 to $40 per ton in France according to locality. The cost in the United States would probably be near $50 owing to higher cost of power, labor and materials.

The process described by Guillet is similar to that described by Cowper-Coles.[2]

The various processes described for the production of electrolytic iron vary from the simple one used by Burgess to the complicated process of Boucher. While the more complicated methods use the cheaper pig-iron and iron ore as sources of raw material, it is doubtful whether the cost of the finished iron is much less than in the simple refining process. The cost of rotating cathodes, removing slimes, solution maintenance, auxiliary apparatus, and the necessity of careful chemical regulation of the electrolyte minimize the advantage of low cost of raw material.

USES FOR ELECTROLYTIC IRON.

Electrolytic iron when deposited by the usual methods is brittle, due to the hydrogen present. In this form it can be easily broken into small pieces and even ground into a powder. By heating the iron to a red

*A paper presented at the Twenty-ninth General Meeting of the American Electrochemical Society, held in Washington, D. C.

[1]References to note numbers, see next page.

heat the hydrogen is driven off and the iron becomes ductile, the ductility increasing with the temperature of annealing.

Brittle electrolytic iron as deposited is highly soluble in acids,[14] being much more readily soluble than zinc. Annealing the iron makes it much more resistant to acid attack than ordinary irons and steels. This property of the brittle iron has resulted in the suggestion that it be used for the manufacture of hydrogen by acid attack in place of zinc and other forms of iron.

The brittleness of the iron and its purity make it an ideal material for melting in crucibles, the hydrogen content having the additional virtue of forming a reducing atmosphere. The brittleness also allows it to be readily broken into small pieces for introduction into the crucible.

The high purity of the iron makes it possible for it to be used in competition with Swedish iron and at approximately the same cost.

It may also be used for pharmaceutical purposes as a base for compounds of which iron is a constituent. Here again its purity is of value.

The much suggested use of electro-deposited iron for electro-magnetic purposes appears to be becoming of commercial importance. While the magnetic qualities of electrolytic iron seem to be superior to the commercial silicon irons its high electrical conductivity counteracts this favorable property.

Electrolytic iron also is used as a basis for scientific experimental work on the various properties of iron where the purest available iron is needed to secure the most accurate data. It is also used as a basis for "pure iron" alloys.

The materials that have been produced and which seem to give the most promise for direct production without further mechanical working are sheets and tubes. By producing these directly by deposition in such a manner as to not require further operations it would be possible to make thin sheets and tubes of great uniformity. In tubes having thin walls made by mechanical processes, these often vary in thickness and it is hoped that this defect will be overcome by making them electrolytically.

EFFECT OF ADDITION AGENTS UPON THE DEPOSITION OF IRON.

The effect of addition agents upon the electro-deposition of iron has been studied by Watts and Li.[15] The solution used for experimental work contained 150 grammes of $FeSO_4.7H_2O$, 75 grammes $FeCl_2.4H_2O$ and 120 grammes $(NH_4)_2SO_4$ per liter with a specific gravity of 1.125 at 20 deg. Cent.

The addition agents giving the best results are given in the following table in order of excellence (amount given is per liter):

a. 6.0 grammes ammonium oxalate.
b. 0.6 gramme formin or hexamethylenetetramine.
c. 2 drops phenol.
d. 4 drops formalin.
e. original solution.

These results show that the deposition of electrolytic iron may be improved by addition agents.

DETAILED ESTIMATE ON COST OF ELECTROLYTIC IRON.

The appended data covering in detail the cost of producing electrolytic iron on a large scale have been kindly furnished by Mr. C. F. Burgess. The plant is assumed to be 1000 kilowatt capacity with an output of 8640 tons per year of 360 days. (See Table I.)

A current density of 10 amperes per square foot (1.1 amperes per sq. dm.) is assumed and an energy consumption of 1 kilowatt hour for every 2 pounds of iron is also taken as warranted by past experimental work.

The most suitable anode material would probably be the crop ends of very mild steel, preferably the product of a basic open-hearth furnace, or even better from concerns which are making the newer higher purity irons. These materials would have the advantages of low phosphorus and manganese and also of the other elements, which should have the least tendency toward sliming and consequent deterioration of the electrolyte.

It probably could be purchased at an average of $15 per ton and would be worth $20 per ton rolled into a form needed for use in the refining tanks. This figure would cover also the freight charges to the plant.

The estimate of Table II shows a total investment of $128,360. This does not cover the total capital required. It does not include, for example, real estate investment other than that involved in $1 per square foot (0.1 sq. m.) of building space; it does not provide for working capital or accumulated stock, nor does it provide for development work which would be necessary.

Table III gives the principal items of operating cost, which show that a figure of about $10 per ton of refined iron is possible. In fact, this is believed to be a liberal estimate. It is larger than the figures given for the refining of copper, and in all probability the cost of refining iron would not be materially greater than that of refining copper. The operating costs, however, do not include interest on investment.

The cost of raw material is taken at $20 per ton, thus making the cost of the electrolytic iron approximately $30. If it would become necessary to use a low phosphorus rolled stock worth $30 a ton the cost would be increased 33⅓ per cent, which would limit the use of the refined iron.

APPENDIX.

Table I.

Estimate on Electrolytic Iron Plant.

Power consumed in tanks........................1000 kilowatts
Output, refined iron..24 tons per day (8640 tons per 360 days)
Refining Tanks—
Made of 2 inch (5 centimeter) cypress lumber, reinforced.
Size, 6 feet 6 inches (200 centimeters) long; 3 feet 6 inches (105 centimeters) deep; 3 feet 8 inches (110 centimeters) wide, outside.
Number, 840.
Floor space per tank, 50 square feet.
Total floor space, tank room, 42,000 square feet.
Cost of each tank—

Lumber, 190 feet, at 5 cents	$ 9.50
Labor and reinforcement	9.50
Fittings, drains, pipings, and conductors	11.00
	$30.00

Amount of iron in each tank—
11 anodes 3 feet (90 centimeters) × 2 feet (60 centimeters) × 1 inch (2.5 centimeters) thick=2530 lbs. (1150 kgs.) per tank
10 thin sheet cathodes.... 70 lbs. (32 kgs.) per tank
2600 lbs. (1182 kgs.) per tank
2600 lbs. at 1 cent = $26.00.
Electrolyte, at 33 cents per cubic foot = $23.00.

Table II.

Cost of Electrolytic Installation.

840 tanks, with fittings, at $30	$ 25,200.00
Electrolyte 840 × $23	19,320.00
Iron under treatment— 840 × 2,600 pounds = 1,092 tons at $20	21,840.00
Total cost of tanks	$ 66,360.00
Cell room—42,000 square feet (3,800 square meters) floor space	$ 42,000.00
Additional equipment— Traveling cranes, pumps, storage tanks, purifying tanks, etc.	20,000.00
Total investment inside switchboard	$128,360.00

Table III.

Operating Costs.

Power, delivered to cells, 1,000 kilowatts at $50		$50,000.00
Engineering and superintendence		7,000.00
Labor, 20 men at $800 per annum		16,000.00
Depreciation—		
Tanks and fittings: 15 per cent on $25,200	$3,780.00	
Electrolyte: 10 per cent on $19,320	1,932.00	
Iron under treatment: none.		
Building: 5 per cent on $42,000	2,100.00	
Accessories: 10 per cent on $20,000	2,000.00	
		9,812.00
Miscellaneous repairs, etc.		10,000.00
		$92,812.00

Total cost of 8,640 tons = $92,812.00
" " per ton = $10.75

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A Comparison of Weight in Its Relation to Horse-Power in Motor Vehicles

Though practically all classes of motorists find hill-climbing at speed their chief delight, and are never tired of comparing the hill-climbing abilities of their own and acquaintances' vehicles, few stop to consider what really governs speed in hill-climbing. What is this important factor? Nothing but the amount of weight carried for every cubic centimeter of piston stroke. It does not follow that the most efficient vehicle is the one having the highest rating of power to the weight carried, but the vehicle possessing the largest engine capacity to weight is usually the liveliest, nippiest, and fastest on hills.

Now, the power of rapid acceleration possessed by the average motor cycle is far in advance of that which can be attained on any other motor vehicle, with the exception of high-powered racing cars (aeroplanes are outside the considerations of these few notes). The reason of this is, of course, to be found in the fact that the motor cycle has a much larger engine, weight for weight, than a car, a light car, or a cycle car, though in the case of the single-seated three-wheelers the last-named class runs it pretty close.

Gear ratios, too, have their bearing upon the case, and, generally speaking, the lower the gear the better will the acceleration be, provided that the speed attained is within the power of the engine; for every engine has its limit in revolutions per minute, beyond which it will not go even when running light. Gears, however, can generally be altered to suit circumstances.

We propose, therefore, to discuss the relationship of weight and cubic capacity as set forth in examples of some of the more usual types. No special machines will be referred to, but the weights may be taken as a reasonable average for the type of machine in question, ready for the road and with a moderate amount of fuel in the tank. The rider or passenger is in every case taken to weigh 154 pounds.

If, then, we find the number of pounds carried by every cubic centimeter of capacity, we shall have some measure of the power of acceleration and also of the ability to climb hills at speed that the different machines possess.

The following tables give some comparative figures for the various type we have mentioned.

SOLO MOTOR CYCLES.

Horse-power.	Cubic Centimeters.	Weight in pounds.			Pounds per Cubic Centimeter
		Bicycle.	Rider.	Total.	
2¾	350	176	154	330	0.94
3½	500	226	154	380	0.76
5	650	256	154	410	0.63
7	990	300	154	454	0.45

It will be seen that the larger power has a distinct advantage, for the 7 horse-power machine has only to propel half the weight per cubic centimeter that the medium-weight 2¾ horse-power machine has. Of course, if the riders of the lighter bicycles were smaller men than those who ride the heavyweights, the difference would not be so marked, but that is by no means always the case. In fact, many a little two-stroke lightweight carries a rider of 14 stone or more.

SIDECAR COMBINATIONS

H. P.	C. C.	Weight in Pounds.					Pounds per C.C.
		Bicycle.	Side-car.	Rider.	Passen-ger.	Total.	
6	770	272	120	154	154	700	0.91
8	990	350	152	154	154	810	0.82

CYCLE CARS AND RUNABOUTS.

H. P.	C. C.	Weight in Pounds.				Pounds per C. C.
		Car.	Driver.	Passenger.	Total.	
8	986	588	154	..	742	0.75
10	1,100	1,400	154	154	1,708	1.55

The standard cycle car has about double the weight to carry and naturally will be left behind, it is capable of a good speed on level or on moderate inclines.

MOTOR CARS.

H. P.	C. C.	Weight in Pounds.				Pounds per C. C.
		Car.	Driver.	Passengers	Total	
10–12	1,460	1,650	154	154	1,958	1.34
12–16	2,300	2,240	154	462	2,856	1.24

Reference to the tables will show that none of the motor bicycles alluded to have a load as high as 1 pound per cubic centimeter, even when a sidecar is attached and two persons carried, while none of the four-wheelers have a smaller load than about 1¼ pounds.—*The Motorcycle* (*London*).

Applying the enamel to a fine bowel.

A flower painter at work in his studio.

The Royal Porcelain Factory at Berlin

Artistic Work That Is Being Carried on in Spite of the War

ONE of the most interesting economical phenomena attending the World War undoubtedly is the fact that interest in art has in no way become less in Germany than in time of peace. Applied arts are flourishing and have found a new branch in German fashion, while one of its most important seats, the Royal Porcelain Manufactory, at Berlin, not only keeps up business as usual, but was able to extend and rebuild its workshops, and to add a new building, mainly intended for exhibition and sale, which holds out new promise for the future.

In the midst of the Thiergarten Park, far away from the bustle of city life, though only at a few minutes distance from the station of the Metropolitan Railway, there is rising a most tasteful two-storied building in *baroque*, well adapted to house the products of porcelain manufacture. Through the main door, flanked by two Doric columns, a high, spacious hall is reached, lighted abundantly by two opposite rows of huge windows. Everything in this sales-hall is white, counters, cupboards, chairs and the rest, and everything is as simple and unassuming as possible, in order not to interfere with the decorative effects of the porcelain. On the first floor there is a sales-hall of the same dimensions, intended only for exhibition of dinner services, and on the second floor, the corresponding hall houses the ceramic collections and a number of exhibits illustrating the making of china. Besides these rooms there are special sales-rooms for technical porcelain—an important export article—a fine dinner hall for workmen and employees (about 690 at normal times) and a new bathing establishment. A covered gallery leads to the factory buildings.

Nothing is more interesting than an inspection of the workshops of the last, unfolding as they do a new world of their own, with a wealth of manufacturing processes, scientific and technical laboratory workshops for applied art and artists' studios, as well as extensive managing offices. On the ground floor there are heaped up raw materials—porcelain earth (kaolin), on the one hand and feldspar on the other—possibly with an addition of sand. Kaolin, the more important component, is of a fatty touch and is unfatted by the other ingredients. Feldspar and sand prevent excessive shrinking in burning the porcelain and act as flux.

After being crushed coarsely, the porcelain earth enters a stirring machine, where under the influence of flowing water the coarse and fine particles respectively are loosened and separated. The mud is carried to a system of channels where the coarser and eventually finer and finer particles are left. The residue is used for refractory earth manufacture, whereas the liquid is conveyed into "settling" basins, where even the very finest particles are allowed to settle. After discharging the clear water, cleansed kaolin eventually remains, which is mixed with the feldspar, crushed and finely ground in the meantime. The mud eventually obtained is sifted through extremely fine sieves, drawn in by a pump and thrown through a filter press, depriving it of sufficient water to make of it a plastic mass. After storage for some time in the cellar this is kneaded thoroughly by means of a special machine, thus becoming homogeneous throughout the mass, and being freed from all air bubbles.

Plaster molds are used as far as possible for molding the china. Round vessels are, of course, made on the potter's lathe, the approximate shape being obtained free-hand, and the definite outlines by means of patterns.

After protracted drying in hot rooms the molded objects are sent to the kiln, there to be baked for the first time at about 1,000 deg. Cent. Though becoming remarkably resistant, the porcelain thus treated retains its porosity. On being next dipped into a mixture of water, glass and kaolin, called enamel, it absorbs this mixture most greedily, the object becoming covered with a thin coating of enamel. The enameled

Openwork decorations are carefully cut by hand into the soft material.

object then is exposed to another baking process at even higher temperature (1,300 to 1,500 deg. Cent.), the porcelain melting down to a dense, translucent material, whereas the vitreous coating is smooth and transparent. The ring furnace of the manufactory comprises twenty-two compartments, arranged in two rows, to which the heating gas is supplied through channels. Valves and slides allow the gas to be introduced into the compartment actually to be heated, whereas others are allowed to cool down or subjected to preliminary heating. The fire of this furnace is kept up throughout the whole year. The porcelain to be baked is enclosed in saggars, protecting it against the direct action of fire gases.

However, china derives a great part of its beauty from the colors and outlines of the painting eventually applied. In the technicalities of painting, especially in preparing porcelain colors, considerable strides have been made of late. Colors are applied either on or below the enamel, the former process being incomparably easier. Colors made in turn of enamel are, at a temperature of about 700 deg. Cent., baked on the enamel. Remarkable facility in handling the brush is required in applying colors on the porous material below the enamel, spreading by means of a blower being preferred in many cases. Inasmuch as the colors, being baked with the porcelain sample, are, as it were, fused with the latter, effects of great beauty are obtained.

The Porcelain Manufactory, in the course of the present war, has created a number of new themes connected directly or indirectly with the daily events.

Nature of Reflex Action

IN an article under the title "The Reflex as a Creative Act" (*Bull. Imp. Acad. Sci.*, Petrograd, November, 1915), the eminent Russian biologist, S. I. Metalnikov discusses the nature of reflex action, and contests the position of those biologists and physiologists who maintain (*a*) that reflex action presupposes the existence of a central nervous system; (*b*) that reflexes are unconscious and involuntary; (*c*) that they are uniform and invariable. If, he says, we concede these premises we are at the outset brought up against a whole series of difficulties. In many of the lower Invertebrata, and in all unicellular organisms, the most careful research fails to reveal any central nerves, yet they react to various stimuli no less than the higher organisms. Further, we can never determine by direct observation whether a reaction is voluntary or involuntary. And, lastly, even as no two organisms are exactly alike, so there are no two absolutely similar reactions. The reactions of Protozoa are never uniform. Even in Amœba they are so varied as to be scarcely ever twice alike. After describing some experiments on Paramecium, the author maintains that every reaction produces a definite modification in the living tissue, and may therefore be considered as closely connected with the creation of the personality, and he concludes a closely reasoned dissertation in these words: "The life of every organism is an uninterrupted creation, and this individual creation, the cause of endless variety, is but a small part of that larger creative cycle which we call evolution."—*Nature.*

Cheap Alcohol

A SOURCE of cheap alcohol to which apparently but little attention has been given is the waste liquor from the digesters of paper mills. It is stated that at one large mill in this country this waste amounts to 250,000 gallons daily, from which 3,000 gallons of wood alcohol could easily be derived. A trial plant for the recovery of this alcohol that will produce 500 gallons daily is being installed, and if the prospects are satisfactory this will be increased. It is said that wood alcohol can be recovered from the waste liquor at a cost of about 15 cents, as against about twice that figure by the present process.

Heavy grinding machine that reduces the feldspar to a fine powder.

One of the large kilns heated by gas where the finished articles are baked.

The Yellow Spot and the Blind Spot as Causes of Visual Error

A RECENT number of *l'Astronomie*, the official bulletin of the *Société Astronomique de France*, contains the following reflections by M. Henri Fischer, director of the Adjunct Lectures at the Sorbonne, on the subject of the structure and defects of the human eye, wherein an ingenious explanation is offered for certain seemingly inexplicable accidents of automobiles and railroad trains:

It is well known that the retina contains in its center an area of limited extent, the *yellow spot*, where the nerve terminations have a special structure: it is upon this spot that there is formed the image of objects we gaze at, for it is this which gives us the maximum of precision in the perception of fine details. Many manuals express its properties by saying it is "the most sensitive point of the eye." This expression contains a cause of error which it is of import to remove, for it might cause one to suppose (and this is, in fact, a very wide-spread opinion) that the yellow spot is more sensitive to light than the adjacent areas. But this is not the case at all. I have often examined, after nightfall, the little luminous spots thrown on the ceiling by the light of the street-lamp shining through the interstices of the curtains; it is easy to prove that the feeblest spots disappear when looked at directly, though visible laterally. Astronomers have long known—we find the observation in the beautiful treatise by Flammarion, "Les Etoiles"—that stars of very feeble luster act in the same way when seen through the telescope. The yellow spot, therefore, far from being the most sensitive point of the eye, is *blind* to very feeble luminosity. This is obviously a very vexatious defect, so far, at least, as astronomical observations are concerned, for it obliges us to look at the dim stars by the lateral portions of the retina, which gives us images not very precisely defined. The conclusion must be drawn that the area of our field of vision which corresponds to the yellow spot must appear more somber than the adjacent regions of the starry sky. Everywhere I turn my gaze, in fact, I perceive this somber spot, which eclipses the tiny stars. It must be variable as to extent and intensity in different eyes; may it not intervene as a cause of error in the appreciation of the photometric brilliance of double stars, one of whose components is dim? May not this explain why such a component has escaped the eye of certain astronomers? These are little problems which merit, perhaps, a discussion on the part of *savants* more competent than a zoölogist. . . .

If we may thus distinguish the yellow spot, how does it happen that the *blind spot* (*punctum caecum*) does not give us the sensation of a black gap? The answer, I believe, is very easy; the blind spot is absolutely deprived of nerve terminations; no luminous sensation whatever, no physiologic memory of an anterior perception can arise there, and consequently no contrast. Hence the corresponding surface of the visual field cannot appear either somber or clear; it entirely escapes analysis. I believe that this defect, though it may be of small account in astronomy, at least presents a very real danger in every-day life. In the course of trips by automobile, when the bright sunlight and the dust obliged me to close one eye, I have often seen, in spite of a sustained attention, a vehicle suddenly appear from I knew not where which it was an urgent matter to avoid. On one occasion I verified the fact that one of these cars was precisely in the field of the blind spot. But I have never had a similar experience by twilight when both my eyes were working simultaneously so as to annul the effect of the *punctum caecum*. This observation has a useful bearing on questions of security. Possibly the omission of signals in certain railroad accidents is ascribable to the *punctum caecum*.

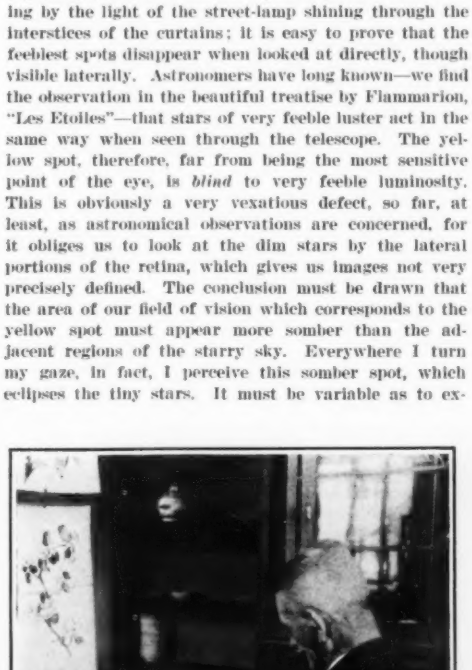
On the occasion of these remarks on vision I am glad to be able to complete an observation which I presented at the session of November 7th, 1915, and to modify a phrase which came from another auditor and was attributed to me by error. The question, which has brought forth some very learned remarks from our colleagues, was to comprehend why we see objects erect although their images are inverted upon the retina. I believe that we must first define the point of departure. The image upon the retina is indubitably inverted; but have we the right to say we see the objects as the inverse of their images? An uneducated man or a child could not have this notion, for they have no means of seeing at one and the same time the object and its image painted upon the retina; far rather, their own body, to which they relate the ideas of high and low, and whose image is also inverted, is seen by them in the same direction as the bodies of other persons. Moreover, the retinal image presents a marked curvature, of which we have no conscious perception.

The opinion long ago expressed by M. Flammarion is, on the contrary, very satisfying; it is not the retinal image itself which is utilized in the mysterious transformations of conscious perception, but it is far, rather, the *direction* which we attribute, by reason of an early and prolonged physiologic education, to each luminous pencil of rays which strikes a nerve termination. But this direction, which passes through the nerve termination, which is excited and through the center of the crystalline lens, is not inverted at all.

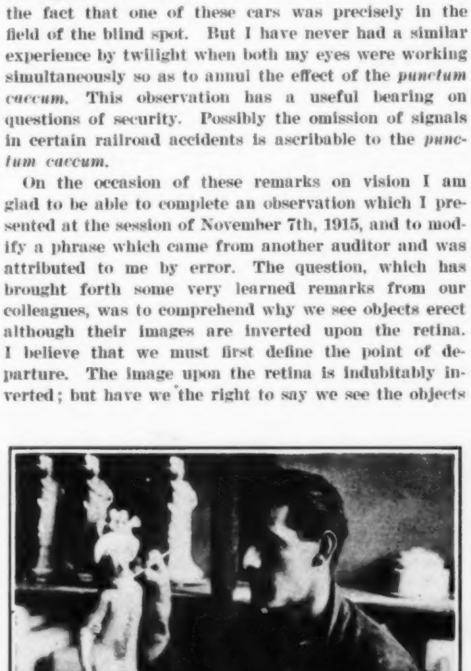
I may observe, moreover, that we may become cognizant of the directions of radiations by means of other organs of sense; in approaching a stove with the eyes shut we can locate without difficulty the direction by the sensations produced on a sensitive nervous surface (face or hand) by heat rays. We can even perceive simultaneously the direction of a stove and that of a block of ice. Have we not here the outline of a sort of image in space, formed by the defined directions of two radiations of different quality? Yet there can be no question here of a real image on the sensitive surfaces of the skin.

The ear is very interesting to consider, for it instructs us as to the directions of sounds which we hear simultaneously in an orchestra. Conceivably, it would be instructive to interrogate the blind upon this point, that our consciousness may succeed in grouping in a sort of exterior image these centers of sonorous emissions of distinct qualities.

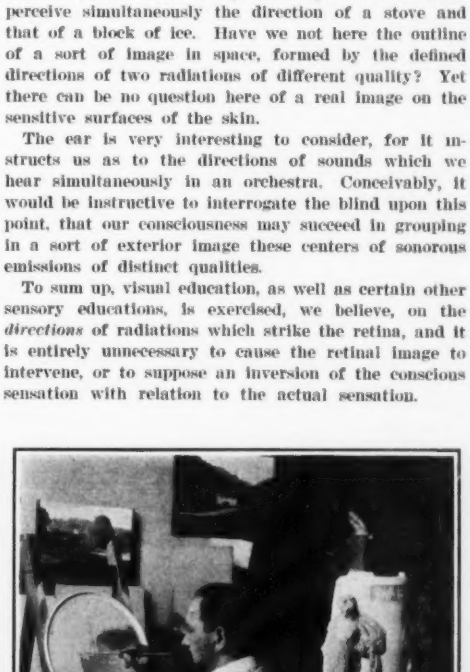
To sum up, visual education, as well as certain other sensory educations, is exercised, we believe, on the *directions* of radiations which strike the retina, and it is entirely unnecessary to cause the retinal image to intervene, or to suppose an inversion of the conscious sensation with relation to the actual sensation.



Painting "on-the-enamel."



A modeler finishing a dainty figure.



"Beneath-the-enamel" decoration.

The Metabolism of Insects—II*

Successive Changes Undergone During Their Post-Embryonic Lives

By August Lameere, Professor in the University of Brussels

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2124, Page 179, September 16, 1916

VIII.

A HETEROMORPHOSIS so pronounced strongly invites a highly revolutionary process of evolution to bring about the disappearance of the larval organs—a complicated metamorphosis, involving an extended period of repose to compensate for the long delay in the formation of the adult.

The holometabolian larva, after its penultimate casting, gorged with the food reserve accumulated in its adipose tissue, is transformed into an inactive nymph like the pupae of the scales, but presenting externally almost the appearance of the imago. It has the eyes, the antennae, the legs and the wings of the adult. The imaginal disks corresponding to these organs have reached this development during the last period of the larval life, but their evolution is nevertheless far from terminated. The nymph has overtaken and passed the prosopon, being now comparable to the last stage of adolescence of a paurometabolic insect, or even to the sub-imago of the ephemerids.

What goes on inside during this time? Two concomitant phenomena: the destruction of the larval organs and the formation of the definitive insect. The more specialized of the larval organs atrophy completely—not only the appendages, but also the lining of the digestive tube, which is expelled bodily. The muscular organization is partially destroyed by a process of histolysis. This is aided by tiny globules of blood, concerning whose precise rôle students have not yet been able to agree, but which are known to contain the elements that go to form the imaginal muscular structure. On the other hand, the organs peculiar to the adult—the genital apparatus, the eyes, and the appendages, as well as the new lining of the digestive tract—are built up at the expense of the pre-existing "outline sketches" mentioned above. Finally the remaining organs—heart, nervous system and Malpighian tubes—are supplied by various means. The reserve albuminoids of the adipose bodies are utilized in part for the nutrition of the tissues in the course of evolution.

The exact biological cause governing metamorphosis is unknown to us. Many hypotheses have been put forward, but none give complete satisfaction. We can in any event agree that the competition of the imaginal organs places the larval organs at a physiological disadvantage which contributes to the destruction of the latter; but what the excitant is that causes the passage of the larva into the pupa we cannot say. We sometimes observe that in a given lot of caterpillars some will become chrysalides at the expected time, while others persist in passing through the winter to transform themselves in the following year. Why? Perhaps, as Rabaud suggests, there would here be a field for experimental research.

IX.

It is not sufficient to explain how the caterpillar becomes the butterfly, it is equally necessary to attempt the discovery of how the butterfly disguises himself as a caterpillar. Metamorphosis is merely a consequence of heteromorphosis, and it is of the latter that the origin should be sought. On this point we can only construct hypotheses, paleontology being unable, at least for the present, to clear up the matter for us; but it is in any event something to feel that the problem is correctly stated.

We have seen that the holometabolian larva has not attained, at the time of birth, the stage of prosopon. Consequently we should be led to expect that at its primordial origin it must have issued from the egg in a state more or less embryonic. It is necessary to inquire under what circumstances of environment such a radical innovation could have been favorable to the animal, and what would have been the primitive adaptations corresponding to the acquisition of these heteromorphic characteristics; for the *raison d'etre* of a characteristic is its utility to the organism under given conditions of existence.

The problem is very simple for the heterometabolians; the larvae of the amphibious members of this group are adapted to aquatic life, those of the cicadas to subterranean existence, those of the scales to a sedentary existence as external plant parasites.

*Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *La Revue Générale des Sciences Pures et Appliqués.*

Now the holometabolians have in their first stages very diverse habits, and yet their larvae present the entire collection of original characteristics which we recognize for this group of insects. This has led to the long-standing supposition that the group was monogenetic. Handlirsch is of a different opinion. He asserts, on paleontological grounds, that the *Neuroptera*, the *Coleoptera*, the *Panorpidae* and the *Hymenoptera* are descended from four distinct heterometabolians. But the writer has been able, by more minute consultation of the fossil evidence, to refute this assertion and to show that all the holometabolians go back to a single type, probably the *Megasecoptera*, upper Carboniferous insects first classified by Brongniart.

What, then, ought the habits of the primeval holometabolic larva to have been? This animal, of embryonic constitution, with short legs and thin skin, fearing the sun and seeing poorly, was not made for a vagabond career. From his birth he had to find, in a more or less damp environment, a shelter and an abundant source of nutrition. He therefore cannot have been a carnivorous hunter over wide expanses. But if aquatic, he would not have lost his facet eyes; if a subterranean dweller, he would not have had short legs. A parasite on other animals he could not possibly have been; and if an external plant parasite, he would have been a suctorian. But he can only have been an internal parasite upon the plant in which his mother had deposited him as an egg. He seems indeed to have dwelt within the trunks of the *Cycadaceae;* this is the hypothesis which we have held since 1892.

There he would find an early appearance [speaking geologically] possible; for there he would have a damp shelter and the food for which his very simple digestive tract fitted him. He required only short appendages and myopic eyes; it was to his advantage to preserve throughout his growth the worm-like form in which he had been born, without any external approach to the adult state to put him in a state of progressive inferiority, and without any external wing-growth to inconvenience him and to get entangled in his close quarters.

There is, as regards the matter of habits, a striking contrast between the heterometabolians and the holometabolians. While an immense number of the latter are found as internal parasites upon both animals and vegetables, the former always live outdoors. (It is necessary to except from this statement the white ants, for while they in general bore into tree trunks, their sexless members are truly apteral.)

The internally parasitic existence of the larvae of these primitive holometabolians, as Henneguy remarks, should apparently have been sufficient to check the acquisition of the adult characteristics and the undergoing of metamorphosis. If all our conclusions are correct, this would be almost the only endoparasite in which definite degeneration is not found; for outside certain crustacean copepods, the *Monstrilla*, we know of few similar examples. But then the holometabolians are the only parasites possessing wings, an incomparable means of dispersion which even the *Ichneumonidae* have retained.

The first holometabolian hexapods having been found in Triassic deposits, Handlirsch has attributed the origin of their metabolism to perturbations brought upon insect life by the glacial period of the Permian epoch, which caused the disappearance of so many of the heterometabolians. He looks upon the larval state as an adaptation to secure a rapid and intense alimentation, and the pupae as a means of preservation against the cold. The writer does not understand just how atmospheric influence could well have led to the acquisition by the larvae of characteristics so very special; and he would point out that the insect does not always pass through the hard season in the form of a pupa. It must be admitted, however, that this hypothesis of Handlirsch is favorable to our thesis, since the endophytic habits adopted by the holometabolians would assure them an advantage over the heterometabolians in resisting the vicissitudes of the extreme climate.

X.

We have seen that the transformations of the paurometabolic insects may progress to hemimetabolism, to neometabolism, or to holometabolism, and that they may likewise degenerate to apometabolism. We recognize, too, an evolution from holometabolism, sometimes by complication, sometimes, on the contrary, by degeneration.

That excellent observer of insect habits, Fabre, has given the name *hypermetamorphosis* to the group of multiple post-embryonic phenomena exhibited by the *Coleoptera* of the family of vesicant parasites *Meloidae*. From the egg emerges a first emigrant larva, the *triongulin*, which, after locating a deposit of food or eggs belonging to another insect, transforms itself into a second larva of sedentary habits. When the latter has attained its full measure of growth it passes into a state of inactivity, the *pseudo-chrysalis*, from which later emerges a third larva, differing but little from the second. It is only after all this that the pupa stage is reached.

Now this is really no hypermetamorphosis at all, for the pseudo-chrysalis is in no way comparable to a pupa. It presents none of the phenomena of histolysis; it represents, as Künckel has clearly demonstrated, a moment of repose in the post-embryonic evolution, quite analogous to the winter sleep of certain caterpillars. Whether this stage is followed by a casting or not, it comes back to the same thing; and the third larva is in fact the same as the second. What is of importance is the fact of double heteromorphosis, the triongulin being a new adaptation of the larva, a sort of larva of the true larva.

This is *hypermetabolism*, a term again applicable to all the other cases, as for example that of the *Mantispa*, where a holometabolic insect presents successive larval states adapted to different environments.

On the other hand, there is to be found among many holometabolians a certain simplification of the evolution process. The insect then becomes apteral. This simplification goes to even greater lengths when the animal, comparably with the female caterpillar, gives over its metamorphosis and reproduces from the larval form, which it then maintains throughout its existence. This phenomenon is also exhibited by the females of certain *Coleoptera* of the family *Lampyridae*.

Finally, we have an altogether extraordinary case in the *Termitoxeniinae*, *Diptera* of the family Muscidae, which by a climax of originality are hermaphrodites—a phenomenon unique among insects. These amazing little motes are the domestic animals of the white ants, who gather and consume a substance that oozes from the excessively swelled abdomen of their "oxen." The latter have their wings transformed into hooks by means of which their masters transport them from place to place. From the relatively large egg of these creatures the perfect insect issues directly.

We have here *cryptometabolism*, the last word in insect phenomena. We may well repeat, with Linnaeus, "*Natura maxime miranda in minimis.*"

An Artillery Chronoscope

THE ordinary stop watch, or chronoscope, has a balance that beats fifths of a second, and as this controls the hand one fifth of a second is the smallest reading that can be had on this kind of an instrument. This, however, has been found too long an interval when timing the flight of a projectile, as it may correspond to 400 feet, which would make artillery fire based on such timing decidedly inaccurate in range. To meet this condition a London maker has produced a chronograph giving beats of a hundred to the second.

There are two ways in which this chronograph can be used. The first is the obvious one of taking the time between the firing of the gun and the explosion of the shell, the setting of the fuses can be checked; also by thus checking the range the condition of the gun can be noted. The other use is for getting the correct range of the guns of the enemy by noting the flash of their guns and the time it takes for the sound to reach the observer. It is then possible to accurately calculate the range of the hostile battery. Extremely nice workmanship was necessary to make a watch that could be started and stopped in the hundredth part of a second repeatedly and accurately.

The Proper Use of Chemicals in the Laundry*

Process Employed in Modern Establishments

By Dr. Herbert M. Shilstone

The greatest specter which you have had to fight is the feeling, common among the general public, that you resort to chemicals for cleaning or whitening fabrics, and that the cleansing power of water is a thing unknown, or at least not taken advantage of, by you.

A few years ago, your president sent me a communication requesting that I call at his office for an interview. I must now admit that, although I had been using the services of laundries for approximately thirty-five years, it was the first occasion on which I had entered the portals of such an institution. During our interview it developed that this laundry was desirous of having general conditions of operation investigated, with a view of adopting such methods as would improve the character of its work. I am not going to burden you with the devious routes through which I passed in studying the chemistry of laundering, but I must admit that I greatly increased by knowledge during this work.

Yesterday, a member of this association, in referring to the subject of advertising, stated that any business can be made a success, if it is properly advertised, provided that business persistently and consistently "delivers the goods." To "deliver the goods" in your case means not only to leave them at the front door, but also to leave them in the condition in which they were received by you, and not in such a state of dissociation that only glue would hold the threads together.

Although the process of cleansing clothes can be expressed as water, more water, and still more water, it is now a fully recognized fact that to clean garments and other linen properly, it is necessary to add to the water a certain amount of cleansing chemicals and also to make use of heat. Both of these agents are good servants, but bad masters; hence it is necessary to make use of their cleansing power by the use of only such amounts as will produce the desired effect without destroying or changing the character of the fabric.

The first chemical, if I may so call it, with which you have to contend, and by no means the least important, is the water. From the laundry's standpoint, there are two classes of water—hard waters and soft waters. Hard waters should not be used either in the washing process or in preparing the solutions which you use. When hard water is used, the lime and magnesia salts contained make compounds with the soap, which are difficult to get out, and which frequently cause yellow or brown stains. In addition to this it is a recognized fact that it is much easier to rinse the soaps and alkalies from the fabric when soft water is used.

Some of you who have very soft waters to contend with may not agree with me in the statement, as you find that even after several rinses your water still will form suds. I may remark that such action is not due to deficient rinsing, but is due to the fact that a minute quantity of soap will form suds in a soft water. By using a hard water, the removal of the soap is apparently rapid, owing to no suds being present; but in fact the soap is still present, in an insoluble compound of lime or magnesia. Through the absence of suds, deficient washing frequently takes place.

The problem of water softening is a very simple one. As a matter of fact, the softening of water reduces itself to the use of soda ash and lime. Except when other chemicals are to be removed, such as iron, I feel safe in saying that the two agents mentioned will do the work in ninety cases out of each hundred. But the process of water softening for your purpose is not a haphazard one; you must bear in mind that it must be your aim to have water which is practically neutral. Excess of alkali, either lime or soda, means the use of large amounts of acid for souring, as the final results in your operation call for the absence of free alkali if good work is to be shown where blue is used.

WASHING TEMPERATURES.

It is important to control the temperature of the water which is used on the clothes, after once a soap is present, by the action of added alkali on the grease contained. Soap is slightly insoluble in cold water, but very soluble in hot water. After soap is present in a batch of clothes, care should be taken not to apply cold water until sufficient rinsing with hot water has been done to remove this soap. Sometimes the wash man will run first cold water in, when he desires to rinse in hot water, and then use steam to heat it. This should be prohibited, as the chilling of the soap causes it to harden and renders it much more difficult to wash in. The ultimate result of this is the formation of yellow around points where this undissolved soap remains.

Generally speaking, the process of washing consists of first soaping the clothes in cold water, running the machine for a few minutes. Sometimes a small quantity of some form of alkali is used in the first water. Next, a hot rinse is used, and most frequently the alkali is used then. The use of warm water at the start is not advisable, as it may cause stains of an albuminous nature to become set and difficult to remove later on.

Next, it is customary to apply the soap, in hot water. At this point the temperature is raised almost to the boiling point. Where two suds are used, the bleach is applied in the second, and followed by sufficient cold rinses to remove the soap and acid produced by the bleach.

The acid should be applied, if possible, when the clothes have been washed free of added alkali; but in any event, the end of this process must show free acid present.

In order to establish the physical effect of the various steps in the customary process of washing, a large number of experiments were carried out by Dr. W. F. Faragher, at the University of Kansas, in 1914, and to whom I wish to give credit for all the experiments mentioned in this paper. Four series of turnover collars, five to a series, were taken. Each series was submitted to successive washings in one of the parts of the washing process—that is to say, one in soap and bleach, one in acid, one in soap and alkali and one in pure water. This treatment was repeated, and in each case until the edges of the collars broke. The following results were observed:

Bleach series—Two collars broke on seventh, one on eighth, and all on ninth.

Acid series—One collar broke on fifth, one on sixth, two on seventh, and all on ninth.

Soap and alkali series—All collars intact on fifteenth.

Water series—All collars intact on fifteenth.

The acid used was oxalic; no rinse was given after the acid was used.

THE DETERGENTS.

Next to water as a cleanser of clothes there is to be considered the action of alkalies and soaps. For a long time the laundries of this country have been purchasing their alkali in the form of what is known as "neutral washing sodas." Some of these consist of a combination of sodium carbonate and sodium bicarbonate.

All experiments which have been made on the use of alkalies, when they are applied in correct proportions in the washing of the clothes, show that there is only a slight damage done to the wearing qualities of the fabric, provided proper rinsing is done. Samples of thread that were soaked in a one per cent sodium carbonate solution showed a tensile strength, before treatment, of 1,700 grammes. After treatment, when the alkali was removed by proper washing, the tensile strength was reduced to 1,670 grammes. The same thread showed only 1,400 grammes when dried without being washed free of alkali.

Probably the source of greatest waste in the average laundry is that which takes place in the purchase and use of soap. In purchasing a soap, there are a few important "Don'ts" which have to be remembered.

Don't buy a soap which contains rosin. This material will produce a yellow cast in the fabrics, and is of no value as a cleanser.

Don't buy a soap which is made from stearic acid. Use a soap the base of which is oleic acid.

In building your soap use about twenty-five pounds of soap to five pounds of soda carbonate.

An ingredient which should be absolutely eliminated from soap is silicate of soda. Experiments have shown that soaps which contain any quantity of this ingredient cause rapid deterioration of cotton and linen fabrics. The silica is deposited in the fibers and renders them brittle. Owing to the use of acids, the silica which is left in after each washing is rendered insoluble and remains in, to be increased in the next washing.

BLEACHES AND ACIDS.

The greatest damage to fabrics by your process is in the bleaching and acid treatments. The most common bleach, and really the least harmful to cotton goods, is to be found in the use of sodium hypochlorite, which is made by the action in chloride of lime on carbonate of soda. I have found the best results to be obtained by the use of eighty pounds of soda ash, dissolved in two hundred gallons of water, and twenty pounds of chloride of lime, which is made into a paste with water, slowly added to the soda solution, which is constantly stirred. This will make a solution which settles rapidly and contains very little sediment, provided all the soda is dissolved. It requires about one gallon of this solution to bleach properly a batch of seventy-five shirts.

In using bleach, it has been found that best results are obtained by separating this from the second suds. Less bleach can be used, as a portion of the gas is consumed by the soap, when soap is present. In addition to this, when the bleach is used in conjunction with the soap, it is more difficult to de-chlor (sour) the goods; hence an objectionable agent is usually left in the fiber.

The use of a chlorine bleach with wools or silk is to be avoided. The action of this chemical on these materials renders them harsh and weakens the fibers. The best bleach for this class of goods is found in sodium hydrosulphite, which gives perfect satisfaction, without any appreciable injury to the fabric.

The extensive use of oxalic acid in the power laundries has been the cause of the slow adoption by the average housewife of this class of service. How frequently you are told, when soliciting family washing, "I don't send my linen to the laundry, because it will not last as long as if I launder it at home." If you had investigated the statement carefully, you would have found, in many cases, that the lady had never tried your service, and only spoke from the information handed to her by someone else.

In the early days of power laundries, your object was to produce white goods with a marked accent on the white. You could not get the benefit of the sun, so you chose the first substitute which was offered to you—oxalic acid. It has taken years for you to wake up to the fact that you may have been producing a nice white tablecloth or collar, but that you were also greatly assisting the department store and the men's furnishers in disposing of their stock. I have at a very recent date had laundryowners dispute the dangers which arise from the use of oxalic acid, and bemoan its high price; but I assure you that the coolie has never done you the harm that the use of oxalic acid has.

Chemical conditions exist in your process which necessitate your using an acid. Oxalic acid has certain advantages over acetic and other weaker acids, in its power to form colorless bodies from iron and also from organic matter, such as fruit stains. But when it comes to a decision between a beautiful white sheet, which lasts only six months, and one which is not so white, that lasts twelve months, if you do the right kind of advertising, it is the twelve-months' sheet which will be taken. From these few remarks you will see that I hold oxalic acid, as a sour, in a very small esteem.

Dr. Faragher made some experiments with a view of determining the weakening effect provided by the use of acids. Cotton threads were dipped in a very weak solution of the acids mentioned, wrung dry and fully dried in an oven. The threads were washed in distilled water before drying. The original strength of the threads was 1,717 grammes. Those that were treated with acetic acid had a strength of 1,611 grammes, while those that were treated with oxalic had only a strength of 680 grammes. Threads that were treated with sulphuric acid, and also threads that were treated with hydrochloric acid, had a strength of less than ten grammes.

Acetic acid has certain advantages over all other acids, particularly as it is driven off at the temperature of the dry room if it is not all rinsed out. It will not act on iron stains with any degree of satisfaction, but will decolorize the oxycellulose formed by the action of the chlorine bleach on the cellulose.

Sodium bisulphate is suitable for a sour, as it liberates any chlorine life in the fiber. On the other hand, it has a very pronounced effect on the fiber, producing about as much destruction as sulphuric acid.

*Abstract of a paper that was read at the recent convention of the Tri-States Launderers' Association. Dr. Shilstone is the official chemist for the organization. Republished from the *National Laundry Journal*.

Machine Guns*

Their History and Construction

THE term "machine-gun" does not include revolvers or magazine rifles or the "quick-firing" guns, the projectiles for which are charged in by hand, notwithstanding that numerous automatic mechanical movements are included in each of these. The machine-gun as now used is fully automatic in action; it has, with some exceptions, the rifle bore and is a true rifle, but the term "gun" differentiates it from the infantry shoulder arm. The magazine rifles, however, helped to prepare the way for the present machine rifles or "guns."

Machine-guns were used in the American Civil War. Twenty-five kinds testified to the inventive genius of that period, but only one survived it—the Gatling. In the Franco-German War machine-guns known as mitrailleuses were employed, and though crude, and so heavy that they had to be drawn by horses, they suggested the potentialities of the new kind of arm. But the menace of the newly invented torpedo-boat in the seventies was the most potent stimulant to the development of the machine-gun.

THE GATLING GUN.

In the Gatling, which was in use until the eighties, there were 6 to 10 barrels, grouped around a central shaft, and revolved with worm gear in the breech, which gear was turned by a crank handle. A feed drum was attached above the breech. A cylindrical cartridge receiver fixed at the rear had longitudinal grooves corresponding with the barrels. Through a slot in a cover hinged over it, forming a hopper, the cartridges were dropped into their grooves from the feed drum above during the revolution of the shaft, ready to be pushed by the locks into the barrels. At the rear of the receiver the lock cylinder, keyed on the shaft, revolved with it, and at the back of this a nut kept the parts together. By the turning of the crank handle the cartridges were forced into the breech, which breech contained the mechanism for pushing them into the barrel, firing them, and withdrawing the empty cases. Each barrel was fired in succession. The gun was mounted either for naval or for land service. Provision was made for locking the gun to fire at one point, or for swiveling it laterally on a pivot to give a "scattering" fire.

A grave objection to this gun from the beginning was that its weight was excessive (7¼-hundredweight for the 10-barrel design), and that 4 men were required to work it, 18 to take it into action. Another serious objection, because it interfered with rapid firing, was the cloud of thick smoke which soon accumulated in front of the gun and obscured the view, as was also the case with other guns before smokeless powders were introduced. Resighting was therefore necessary when the smoke lifted, because the gun was supported unsteadily on one pivot, and the jar of the firing threw it off the sight. Sometimes, too, a cartridge would not fall properly into its place and got jammed, and then the drum had to be cleared. The gun was originally of 1-inch caliber, firing a 3¼-ounce lead projectile, with a muzzle velocity of 1,427 feet a second, but the later ones were made of rifle caliber. Under the most favorable conditions they could fire only 600 rounds a minute from 10 barrels.

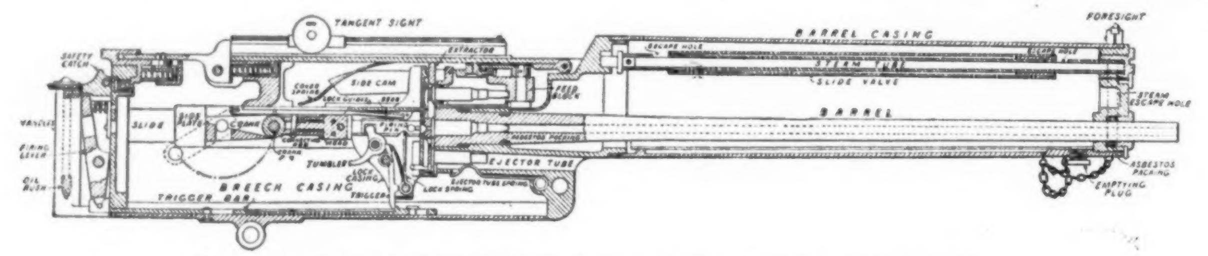


Fig. 1.—Longitudinal section of Maxim machine gun, showing the parts in position for firing.

THE HOTCHKISS GUN.

Named after their inventor, an American, who established works at St. Denis, near Paris, the Hotchkiss guns were used more than any others in the early eighties. They were 5-barrelled revolving guns, and were constructed in calibers of 37 millimeters (1.45 inch), 40 millimeters, 47 millimeters and 53 millimeters (2.25 inches). They varied in weight from 76.2 pounds to 81.4 pounds, and the projectiles from 1 pound to 5.98 pounds. They were adopted by France, Germany, Russia, Italy, Austria, Greece, Chile, China, Holland, Denmark and the United States for the secondary batteries of ships.

The guns comprised a group of 5 barrels, of 37 millimeters caliber for naval service, revolving round a central shaft, and provided with a cartridge feeding hopper, a breech block containing the firing mechanism, and a hand crank for operation. Each revolution of the crank handle fired one barrel, extracted one cartridge and began the loading of another barrel. Only one barrel, therefore, could be fired at a time, and this fact put the gun at a disadvantage by comparison with the Nordenfelt. In a trial of a 4-barrelled Nordenfelt and a 5-barrelled Hotchkiss the former fired 935 shots in 5 minutes, the latter only 250 shots. The mechanism was somewhat intricate, partly by reason of the momentary pauses that were necessary at certain stages. Yet it proved efficient both for naval and for field service, until displaced by the much lighter Maxim.

THE NORDENFELT GUN.

The Nordenfelt guns, named after their inventor, a Dane, were manufactured in a large range with an equipment of barrels, numbering either 1, 2, 3, 4, 5, 7, 10 or 12. The 4-barrelled gun was termed the anti-torpedo-boat gun. The barrels were arranged in line in one horizontal plane. They could be fired singly, or in such rapid succession as to give practically volley firing. The locks were worked by moving a hand lever backwards and forwards—a very tiring operation, more so than turning a crank. The cartridges were contained in a square box, the "hopper" placed above the gun and having as many compartments as there were barrels, and each compartment contained a dozen cartridges. When the hand lever was pulled back, the empty cartridges were extracted and fell down, new ones dropping from the hopper to take their place. The forward movement of the lever pushed the cartridges into the barrels and fired them. The speed of firing therefore depended on the rapidity with which the reciprocations were made. From a single barrel about 180 projectiles could be fired in a minute, while a 12-barrelled gun would fire 1,200. Two men were required to work a gun, one to get the sights, the other to move the lever. Calibers ranged from 0.45 inch to 1.5 inch.

THE GARDNER GUN.

In 1882 the Admiralty, after exhaustive trials, gave an order for 275 Gardner guns, the action of which was wholly automatic, except that the cartridges had to be fed by the turning of a crank handle. The usual number of barrels was either 2 or 5, though single-barrelled guns were also made. The barrels were arranged and fixed in one horizontal plane similarly to the Nordenfelt. The turning of the crank handle imparted, through cam mechanism, a transverse movement to the cartridges in their carrier. When a cartridge came opposite the bore at the breech end, the lock moved forward bodily, thrusting the cartridge into the chamber of the barrel. The mechanism was so designed that, while the rotary motion of the crank was continuous, the transverse motion of the cartridge carrier and the movements of the lock were intermittent and alternating. When the pause in the transverse movement of the carrier occurred, the lock was thrown forward to push home the cartridge which was resting on the carrier. Simultaneously the exploded cartridge case was extracted and dropped. A bell-crank action drew back the firing pin to the cocking point and released it. At every revolution of the crank a shot was fired, and a spent case ejected. Long official tests of the Gardner and the Nordenfelt guns resulted in favor of the former, the advantages credited to it being simplicity of mechanism, facility of removal and accessibility of parts, strength and endurance, rapidity of action, regular supply of ammunition, and a very good principle of extraction. A 2-barrel Gardner fired 236 rounds in half a minute, and 1,000 rounds in 2 minutes and 57 seconds.

DEFECTS OF EARLY TYPES.

The chief function of the early machine-gun was, as already stated, that of repelling the attacks of the new torpedo craft. Very quick and accurate training and elevating were therefore necessary, and consequently heavy, slowly-moving guns were inadmissible. It was necessary that one man should be capable of pointing the gun quickly, so that guns of large caliber to fire heavy shell were ruled out, and only small shell were employed. Although a bursting shell would scatter, and some of the pieces might strike the boat, yet to penetrate it a massive shell would be necessary, which would require a gun too heavy to be manipulated. For these reasons the employment of shell fell into disuse for the machine-guns, and single shots ranging from those of rifle caliber to about 4 pounds weight were adopted, chiefly those of from 1 pound to 1½ pounds.

The machine-guns of that period belonged to one or other of two systems—the volley firing, and the continuous system, of which the Nordenfelt and the Gardner represented the volley, and the Gatling and the Hotchkiss the continuous or successive firing. The volley system possessed the advantage of a certain spread of the missiles, which in the other type was accomplished by lateral training of the guns. The continuous firing, however, rendered these guns very unsteady. Again, a flat trajectory was obviously very necessary, but could be secured only by a high initial velocity and a projectile of small diameter. It will thus be seen that the conditions which had to be met were rather antagonistic to each other.

Further, all the early machine-guns relied on hand operation for firing every individual shot. The Nordenfelt was worked, as we have seen, by a reciprocating lever, the others by a crank. A result was that the guns were rendered unsteady, and they therefore required firm bases. Another objection was the liability of the guns to be thrown temporarily out of action owing to cartridges "hanging fire."

RECOIL VERSUS NON-RECOIL.

In the eighties, comparisons were being made between the advantages claimed for recoil and non-recoiling systems. The idea of utilizing recoil was an old one, but was not successfully applied until it became practical in the Maxim gun. The automatic feed of the cartridges up to that time was believed to be inconsistent with a recoiling mechanism, because of the shock that would be given to the cartridges unless undesirable complications were introduced. It was held also that recoil must interfere with accuracy of aim. The application of springs to store and give out the energy of the recoil was considered objectionable. But the great advantages which earlier experience showed the recoil to possess over the hand-worked guns insured the triumph of the principle in the Maxims. The number of rounds fired by a single barrel was more than doubled, manipulation was easier, and a gun would continue firing until the cartridges were exhausted, even though the gunner were picked off. The Maxim was the first gun which required neither operating crank nor reciprocating lever, and the result is that the other types have disappeared. The energy derived from the recoil performs all the functions of loading and firing and extracting the cartridge case.

PROBLEMS INVOLVED.

The intricate nature of the difficult problems involved in designing *ab initio* an automatic gun may be conceived from a consideration of the different methods

*Engineering Supplement of *The London Times*.

which might be employed to work an automatic gun by means of power derived from the burning powder. The power might be derived (1) from the gases escaping from the muzzle of the gun, either by employing them as an ejector to produce a vacuum in a chamber near the muzzle of the gun or by utilizing their pressure directly; (2) from the recoil of the entire gun; (3) from the recoil of the barrel, the breech block, and the lock; (4) from a backward movement of the cartridge in the chamber at the instant of exploding; (5) from only a portion of the cartridge moving backwards; (6) from the elongation of the cartridge at the instant of exploding. Mr. Maxim decided on the third. The years 1883 and 1884 were prolific of patents taken out by him, showing various ways of arriving at the results desired. All possible covering methods were conceived and patented in different countries, so barring the possibility of infringement by rivals. They are interesting now as illustrating stages in the story of development, but few of them bear more than a remote resemblance to the mechanism of the gun as at present made. By the end of 1885 he had taken out over a hundred patents in connection with his gun.

MECHANISM OF THE MAXIM.

The Maxim gun is operated automatically by the recoil of the barrel and of 2 recoil "side plates," which carry the lock and the shaft of a crank. These move relatively to the non-recoil portions, which include the rest of the mechanism, namely, the water-jacket and its parts surrounding the gun-tube, and the outside plates and parts which enclose the breech mechanism.

the crank rotates, through the connecting-rod, the "tumbler" on its axis and so draws the "firing pin" to the rear. This withdrawal compresses the two arms of the "lock spring," forcing the nose of the "trigger" under the "tumbler," which pushes the firing pin so that it is brought under the bent of the "sear," which is forced into the bent of the "firing pin" and so prevents it from flying forward.

After the recoil is spent, the barrel is brought back to its original position by the tension of the spiral spring (Fig. 2). During its return another loaded cartridge is brought forward into the feed box by the movement of the cartridge belt. The pull of the spring unwinds the chain from the fusee and turns the crank into the position for firing, putting the lock into its forward position. The return is accelerated by the action of the crank handle in striking the buffer spring. The moving forward of the lock thrusts the new cartridge into the barrel and the empty case into the ejector tube (Fig. 1). The empty case is released and held in the ejector tube with an "ejector tube spring" to prevent its return. The safety "sear" is lifted before the lock can fire, and the trigger is tripped, releasing the firing pin, and firing the gun.

The cartridges are fed by means of a canvas belt which passes through the "feed block." The belt holds a much larger number of cartridges than a box; the magazine being below, instead of above, as in guns where feeding is by gravity, offers no target to the enemy; and, the firing being automatic, instead of by a crank or handle, the aim of the gun is not disturbed.

(Fig. 1) permits the steam to escape. The first two are closed, the last is left open and in connection with the steam tube. Asbestos packings prevent the escape of water. The escape of steam is controlled by the "steam tube" with its "slide valve" (Fig. 1). The valve slides backwards when the gun is in elevation, and forward when in depression. In each case a hole in the steam tube is uncovered, front or back, above the water level, through which the steam enters the tube and escapes through the barrel casing.

CALIBERS EMPLOYED.

The Maxim used in the British army service is of rifle caliber (0.303 inch), but precisely the same mechanism is embodied in guns of different calibers for other European nations, ranging from 6 millimeters to 11 millimeters. The rifle cartridge of 0.303 inches (7.7 millimeters) used in the army is adopted in order that the same bullets may be served out for rifle firing and for Maxims. It weighs 215 grains, and is made of lead cased in cupro-nickel.

The heavy Maxim guns, or "pom-poms," are used chiefly as naval weapons. They are of 37 millimeters caliber (1.457 inches), and fire about 300 rounds a minute, the shells weighing about 1¼ pounds. The guns are mounted in various ways for naval and for land services. In essentials they resemble ordinary Maxims, but their greater weight entails some modifications.

As with the Maxim, the recoiling portions comprise the barrel, the recoil plates and their connections, the lock and its parts, crank and crank handle, but the

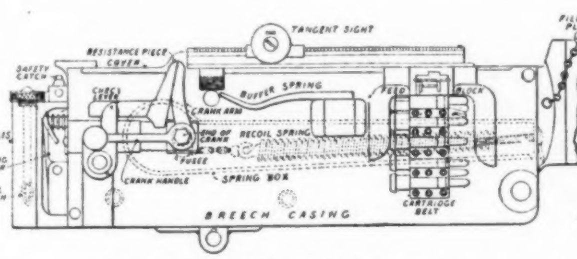


Fig. 2.—Side elevation of Maxim gun.

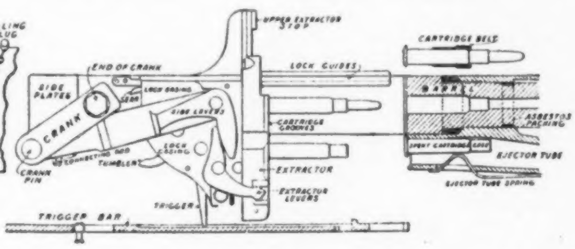


Fig. 3.—Side elevation of breech mechanism with the lock fully recoiled.

The first shot is fired by the pressure of the hand on a double button placed at the extreme rear of the gun between the two handles. This operates a "firing lever" (Figs. 1 and 2), which draws back a "trigger bar" (Fig. 1), a projection on to which releases a "trigger," a cranked "tumbler," and the "firing pin." When a "safety catch" is thrown down it prevents the lever from being pressed forward. So long as the pressure is maintained on the double button, the gun will continue firing while any cartridges remain in the belt. Simultaneously with the discharge the breech is closed by the "lock" (Fig. 1) and held securely in position by a "connecting-rod" which is attached to a "crank" near the rear end of the breech casing. This crank is provided with a handle at the right hand outside the casing (Fig. 2). The crank cannot be moved by the pressure of the explosion, but only under the action of the recoil, or by the handle attached to it.

LOADING AND EXTRACTION.

The recoil, of about 1 inch, withdraws the spent cartridge case from the barrel and also takes a live one from the belt (Fig. 2). These results are dependent on the recoiling of the barrel, which causes a "crank arm" that stands at right angles with the crank, to strike an abutment or "resistance piece" (Fig. 2), from which the turning of the crank results. The arm is curved in such a way that an accelerated motion is imparted to the crank, and the end of the crank handle makes contact with a curved "buffer spring" outside the casing and is cushioned. At the same time the "recoil spring" (Fig. 2) is extended by the recoil of the "barrel" and the short piece of chain at the end of the spring is wound on a "fusee" on the "crank pin," thus extending the spring slightly more. The spring is enclosed in a "box" at the left side of the breech casing. One end of the box receives the anchorage of the spring at the front, the other end of the spring being connected to the crank by the chain and fusee. The crank being thus turned downwards draws the connecting-rod along and down with it, and also the "lock" to which it is attached at the end opposite to its connection with the crank. During this movement backwards an "extractor," provided with horns (compare Fig. 3), takes the empty cartridge case from the barrel and a live cartridge from the feed-belt, which has been moved transversely. The "extractor" drops, and brings the live cartridge into line with the chamber of the barrel and the empty case into line with the "ejector tube." The turning of

The action of the "feed block" depends on two movable pawls in it which are connected to the barrel by a lever. The recoil therefore moves them, and under the action of a spring they engage behind a cartridge in the belt and move it towards the chamber. As the barrel returns, they place the cartridge immediately above the chamber. Messrs. Vickers provide a machine for recharging the belt with cartridges which are fed through a hopper. A handle being turned, the belt is refilled at the rate of 6,000 bullets an hour.

ACTION OF FIRING.

To start firing with a new belt of cartridges, the tag end of the belt is inserted through the feed block from the right, and pulled through to the left as far as it will go. The crank handle is then turned until it touches the buffer spring. This draws the lock backwards, and the extractor drops into its lowest position. The crank handle being then released and carried back throws the lock forwards, when the extractor rises and takes hold of the base of the cartridge in the feed block. The crank being now turned forward, the lock is pulled back, the extractor pulls the cartridge from the belt and places it in a line with the barrel. The belt being drawn to the left as far as it will go, the second cartridge comes into place over the chamber of the barrel. Then the handle being released, the lock goes forward and inserts the cartridge in the barrel, and the extractor rising takes hold of the next cartridge in the belt and the gun is ready for firing. Firing will continue only so long as the button at the rear remains pressed forward. If the button is released after a discharge, a single shot only will be fired. As the gun is still loaded, firing can be renewed by pressing the button again. Jamming cannot occur because if a cartridge should hang fire, the breech, being closed at the instant of striking, cannot be opened automatically except by the power locked up in the cartridge itself, and this power is not developed until the cartridge explodes. As the breech, therefore, does not open till after the cartridge has exploded, the cartridge cannot be withdrawn in the act of exploding.

The water in the barrel casing has to be maintained in sufficient quantity to prevent the barrel from being uncovered. It begins to boil when the gun has fired about 600 rounds rapidly, and afterwards about 1½ pints are evaporated per 1,000 rounds. The casing holds about 7 pints of water. The water is filled through an opening near the breech (Fig. 2), and is drawn off through another near the muzzle; a hole adjacent

barrel is provided with trunnions to which the recoil plates are attached, and a hydraulic buffer controls the recoil. The fore part of the barrel is encircled by a spiral spring which fulfills the function of the detached spring in the Maxims. This spring is compressed about 1½ inches by the recoil of the gun to that amount, and the reaction brings the barrel back into the firing position, together with the recoil plates and the mechanism which they actuate. Also the crank shaft has a volute spring attached to it which is put into tension by the turning of the crank.

METHODS OF MANUFACTURE.

There are about 280 parts in a Maxim, and all are interchangeable. Forge, foundry and machine shop are laid under contribution. The largest forging, the barrel, is drawn down from a bar of high grade steel under a steam hammer. Though it takes the rifle cartridge, the barrel is proportioned differently from the rifle barrel, being much larger at the breech end. It is bored and rifled, and the chamber is recessed and turned by processes similar to those which are performed on rifle barrels, described in the article on the modern rifle, published last month. In addition, the breech is hardened internally to enable it to withstand the high temperature caused by the rapid firing. This is done after the rifling, and is effected by enclosing it in a muffle and introducing an injection pipe through which oil is forced and afterwards water. It is corrected with an emery bob and finish-turned. Copper is deposited on the outside surface to protect it from rusting in consequence of being enclosed in the water chamber. A very large number of drop forgings are required for the lock frame and its parts, for the recoil plates, the crank, the connecting rod, etc. A great deal of milling, drilling and reamering is done on these, using jigs and fixtures. In all, about 550 separate machining operations are required, and about 950 gauges are used, irrespective of the fitting parts and of the manufacture of the mountings. On the pom-pom 770 operations are performed by machine tools. The amount of reduction on some parts is very large. The lock frame forging weighing 25½ pounds is reduced to 10½ pounds by milling, slotting, drilling and reamering operations.

Bronze castings are used for the tube of the water jacket, the rear block and the front cap. In one type the tube is of steel with corrugated gills. The tube is polished outside and screwed at both ends. The rear block is a cored casting screwed within the water

jacket at its front end and extended to the rear and bored to receive the barrel. It fits the breech casting with two dovetails. The barrel makes a close sliding fit in this casting, and the joint is cannelured and packed with asbestos. The tube is adjusted with the "foresight" at the front end exactly vertical. The cap, also of bronze, is screwed within the front end of the tube and its bore is also packed with asbestos, where the barrel slides through it, a gland confining the packing. The feed block for feeding the cartridges is a bronze casting.

THE LEWIS GUN.

A recent design of machine-gun, used largely in aeroplane service, is the Lewis, of American origin. It is of rifle caliber only, is very light, weighing only 25½ pounds, and requires no mounting, being handled like a rifle. Yet it will fire from 400 to 700 rounds a minute automatically after the discharge of the first bullet.

The mechanism is operated by a portion of the powder gases which are generated at each discharge, and the recoil is eliminated by the friction of the gases, which is approximately equal to the recoil. The rapidity of the firing depends on the quantity of gas admitted and on the tension of a spring. The gases are also utilized to prevent the temperature of the barrel from rising above 350 to 400 deg. F. The cooling arrangement consists of a long tube of aluminium encircling the barrel and surrounded with radiating vanes, along which air is drawn by the action of the gases. The cartridge magazine, of sheet steel, holds 50 rounds. It can be removed and another substituted in 2 seconds. The cartridges, arranged spirally, are taken from the magazine by an operating rod, which is itself moved by the powder gas from the previous explosion and which actuates the numerous automatic movements of the gun.

Asphyxia from Defective Ship-Board Ventilation

Fatal accidents take place from time to time on board ship as a result of faulty or imperfect ventilation. Generally speaking, these accidents are the result of poisonous and explosive gases from consignments of cargo, as, for instance, ferro-silicon, which when acted on by moisture evolves phosphoretted hydrogen, often accompanied by arseniuretted hydrogen. A number of examples of shipping fatalities from this cause will be found in a special report on the subject issued by the Local Government Board in 1909 (Cd. 4958). Occasionally, however, in the absence of proper ventilation, changes in the normal oxygen and carbon dioxide air content, brought about in various ways, may result in serious mishaps. As far as my experience goes these changes are of two types. A condition may arise in which some of the oxygen in a compartment is used up, while the normal CO_2 content is unchanged; while, on the other hand, the amount of CO_2 may be much increased at the expense of the existing oxygen.

The first of these two types is, of course, the least dangerous. The following is a good example of it:

An empty oil-tank arrived in Singapore. Her after-cofferdam had been filled with Suez water, most of which had been used, and the compartment had been battened down for about a month. When the compartment was first opened several men who attempted to enter became unconscious. After being rescued and removed to the fresh air they all recovered without further mishap. An analysis of air in the compartment showed that there was no petroleum vapor and that the CO_2 was normal. The oxygen, however, had fallen to 15.4 per cent. The result was, therefore, merely an oxygen starvation, which, if not too long contained, could be easily recovered from. The only reasonable cause which could be discovered for the condition was a process of rapid oxidation of the bulkhead ironwork (in the presence of closure, heat and moisture), leading to a large abstraction of oxygen without other chemical action.

With regard to the second type mentioned above, two cases have come to my notice, both of which were attended with fatal results.

A ship named the "Merapi" arrived from China on April 28th, 1908. When her lower holds were opened up for the removal of cargo two of the ship's crew who attempted to enter the hold fell down insensible. They were removed after a little time, but artificial respiration was tried without success. On analysis the air of the hold showed oxygen 8.6 per cent and CO_2 11.8 per cent. I was on leave at the time, and could, unfortunately, get no particulars as to the ventilation of the compartment nor the composition of the cargo.

The second case was a still more remarkable one. A Dutch steamer, the steamship "Jacob," arrived in Singapore on December 22nd, 1915, with general cargo from Amoy and Swatow and 1826 'tween-deck coolie passengers. The passengers were all healthy on arrival and were given pratique at the quarantine anchorage. The ship then proceeded to the inner roads to discharge her cargo. This cargo had been battened down in the lower holds for 6 days of a tropical voyage. On opening one of the for'ard holds (No. 2) 2 of the Chinese crew descended, but immediately fell insensible on the top of the cargo. All attempts to bring them up were unsuccessful, until the hatch cover had been removed for some 10 minutes. The men were then apparently dead. Artificial respiration was continued for some time, but without avail. Spaces between cargo bales enabled me to obtain a sample of air from near the limber boards, which, on subsequent analysis, disclosed the following remarkable figures: Carbon dioxide, 22.25 per cent; oxygen, 1.86 per cent; marsh gas, 0.30 per cent; nitrogen, 75.29 per cent. When the hold had been properly aired after an hour or two I was able to go down and make a survey. The air was hot, slightly aromatic but disagreeably acrid. There had been originally 2 ventilators communicating with that hold. The for'ard one traversed the 'tween-deck intact and ended as a 6-foot shaft above the main deck. This shaft was fitted with a fixed mushroom top, and could therefore at best only act as an uptake, but would have no action at all in the absence of other ventilating openings or intakes. The second ventilator was situated aft, and, like the first, traversed the 'tween-deck intact, but was then diverted in square section through some cabins and was supposed to open on the upper boat deck. The opening, had, however, been permanently decked over, seemingly for a long time. There had, therefore, been a condition of air stasis for 6 or 7 days in hold three-quarters full of cargo, and at a temperature probably increased by "wild-heat" to over 90 deg. Fahr.

Under such circumstances the composition of the cargo was the important question. A few sacks of soy beans, sugar and cooked rice comprised the smaller portion. There were also 277 baskets of garlic and over 1,000 large wooden tubs of fresh oranges. The rest of the space was occupied with bales of Chinese paper and baskets of fowls' eggs. The replacement of all the oxygen by carbon dioxide must have been brought about by respiration of the oranges and garlic in the absence of any ventilation; and the high temperature was probably a contributing factor of importance.—*The Lancet.*

A New Kind of Gas Furnace

Gas is now being extensively employed for heating purposes in manufacturing plants with great success, some of the uses to which it has been put being case-hardening, hardening and tempering steel, general heat treatment and annealing; but there are some objections to the furnaces commonly used. A furnace operating on a new low pressure system is described in the *London Daily Telegraph*, which shows many advantages, and which may be successfully applied to many different kinds of work. In these furnaces means have been adopted to heat the whole of the air supply necessary for combustion, which takes place in the furnace chamber, in such a manner as to render it unnecessary to employ the usual bunsen burners with a secondary air supply. Combustion of the mixture of gas and air is so near perfection that no excess of air is required, and, therefore, no heat is dissipated by the carrying-off of the excess air at a high temperature, as is the case with furnaces less well regulated as regards the admission of air. The combination of the entire preheating of air with the complete theoretical proportions of gas and hot air results in very economical working, the only heat losses being those necessarily incurred by slight radiation from the outside of the furnace and from the flues.

The working of the furnace may be briefly described as follows: Town gas at the normal pressure enters the furnace-chamber through a series of tubes from the gas-main supply. Air at approximately 2-inch water-gage—the same pressure as the gas, or thereabouts—enters the fire-brick lining of the furnace through a series of tubes from the air-main supplies, and travels down the side and along the bottom of the furnace through fire-clay tubes. The air, thus efficiently preheated, meets the incoming gas as described above, at which point combustion takes place. The products of combustion then pass along the under-side of the furnace before entering the flue or flues, the air for supporting combustion above described being preheated by the waste products. The local heating effect of the blast-flame and usual combustion-chamber are thus obviated.

A reducing atmosphere may be maintained under the most economical conditions by simply diminishing the pressure at the air-main. Air is usually supplied by a fan; so that the expensive blowers, with their costs for power to drive them, can be dispensed with. By the use of valves or cocks upon the main gas and air supply-pipes, the furnace may be regulated for temperatures to a very fine degree. It is usual to fix pressure-gages on the outlet side of the cocks or valves; so that, having first arrived at the correct respective pressures of gas and air to give the results desired in the furnaces, the subsequent regulation is simple—it being only necessary to close or open the valves to give proportionate pressure of gas and air. For example, the pressures of gas and air to give a certain temperature are respectively 10.10ths and 8.10ths of an inch. To reduce the consumption to one half, the valves are reduced to 2.5 inches for gas and 0.2 inch for air, when the exact mixture as before the reduction is maintained.

The method of regulation saves a great deal of trouble, obviating the adjustment of numerous gas and air cocks. Local adjustment can be made, if desired, by the usual taps or gas inlets and slides on the air-tubes. It is desirable (particularly where a non-oxidizing atmosphere is required) to work the furnace with a slight pressure inside it—i. e., a small amount of flame should come out of the peepholes in the door when these are open. This prevents the indrawing of air through the door—a condition which should be avoided in the construction of furnaces.

Each flue is efficiently controlled by double dampers, and it cannot be too much emphasized that, in order to obtain the best results in this or any other furnaces, the flue regulation must be looked to when altering the rate of combustion. When the above-mentioned details have been attended to a perfectly even temperature throughout can be depended upon, and the conditions of heating can be either neutral, reducing, or oxydizing. The floor of the furnace may be constructed to take any weight of material desired per square foot; bricks may be used in lieu of floor tiles. Furnaces can also be of the bogey type if required. For forging furnaces, crucible, and lead and salt bath hardening furnaces, the principles of construction are the same, with some slight modifications.

A point worthy of note is the complete absence of noise usually prevalent with gas and air blast furnaces, which is a matter at times worth consideration where a number of furnaces are working together in one shop. The absence of cutting heats, which destroy brickwork and tiles, is another advantage, and means that the furnace lining will last must longer.

What Radium Looks Like

Radium is a metal and is described as having a white metallic luster. It has been isolated only once or twice, and few people have seen it. Radium is ordinarily obtained from its ores in the form of hydrous sulphate, chloride, or bromide, and it is in the form of these salts that it is usually sold and used. These are all white or nearly white substances, whose appearance is no more remarkable than common salt or baking powder. Radium is found in nature in such exceedingly small quantities that it is never visible even when the material is examined with a microscope. Ordinarily radium ore carries only a small fraction of a grain per ton of material, and radium will never be found in large quantity, because it is formed by the decay of uranium, a process which is wonderfully slow, and radium itself decays and changes to other elements so rapidly that it is impossible for it to accumulate naturally in visible masses. Minerals that carry radium, however are fairly easy to determine. One of them, pitchblende, as generally found, is a black mineral about as heavy as ordinary iron, but much softer. The principal radium mineral, carnotite, has a bright canary-yellow color, and is generally powdery.—*U. S. Geological Survey Press Bulletin, No. 267.*

New Manufacturing Methods

In times gone by it was the boast of many manufacturing establishments that they made in their own establishments every individual part of the machine or product they turned out. This was never literally true for any establishment, as it obviously would not pay to make every nut and screw used, when specialists in such parts could turn them out cheaper and better. Especially is this the case where the number of a certain part required is not great enough to keep the necessary machinery constantly employed. As a natural consequence the number of shops making specialties, for the use of other manufacturers, has greatly increased of late years. An example of this is in the building of automobiles, for which springs, axles, tires, wheel rims and wire spokes, not to mention the great variety of electrical accessories, all made by independent specialists.

The Story of the Grinding Wheel*

How It Has Developed and Some of the Odd Uses to Which It Is Put

By C. W. Blakeslee

Looking back several years calls to mind the crude and imperfect state of the grinding industry in those days. I call to mind how imperfect was the practice of using grinding wheels compared to the present time. Very seldom was an order received with the request for any particular class of grinding. Usually the order would simply specify the size of the wheel only. If the size was to be had the customer received the wheel and no further questions were asked and very few complaints, if any, made as to the action of the wheel upon the work. Wheels that were furnished for general work or rough grinding were evidently as good for tools. If a sharp, keen edge could not be obtained on this class of wheel they would grind as near as possible to the desired sharpness with the wheel, and the final keen edge was finished on the old oilstone, thus eliminating the necessity of the wheel manufacturer losing sleep over the unsatisfied customer.

Without the determination of progress on the part of the grinding-wheel manufacturers of the United States, those conditions would be the same to-day. Not an industry of any kind has used greater energy to bring efficiency and lower cost of production to the steel and iron-working plants of the world than have the grinding-wheel manufacturers. Very few, if any, materials of any kind, including steel, iron, brass, wood, aluminium, glass, leather, rubber, etc., have not in some stage of their manufacture been introduced to the grinding wheel. The use of the grinding wheel is unlimited. In every manufacturing plant, both large and small, regardless of the class of material used, the grinding wheel is in evidence.

The most peculiar order which I have ever received was an order for a 2 x 12-inch wheel for grinding hams. I at first thought some joker was on the job, but decided to make closer investigation before casting the matter to one side. I finally found that the customer realy wanted the wheel and wanted it for the purpose of grinding hams. It proved to be one of the large packing firms at the Chicago Stock Yards. The wheel was furnished accordingly and did the job of surfacing off the sides of hams preparatory to stenciling them. This further demonstrates there is no limit to the use of the grinding wheel.

ACCIDENTS THROUGH CARELESSNESS.

The lives that have been lost and the serious injuries that have happened in the past twenty years, to my knowledge, through the unnecessary breakage of grinding wheels is appaling. In late years, however, a small percentage of serious accidents have happened in comparison to former years, due to the fact that the safety-first campaign has been strongly in evidence Safety devices have been installed on the grinding stand and more consideration in every way has been given the conditions surrounding the grinding wheel. The users in general have finally conceded the fact that the wheel manufacturers use every precaution to make the grinding wheel as safe as human genius will permit, and that they must do their part toward giving the wheel the proper protection against breakage. Many lives have been lost through the use of worn out grinding-wheel stands that should have been sent to the cupola years before they were. Some of these grinding stands I have seen in operation over twenty years with worn-out bearings permitting the spindle to shake over ¼ inch, the spindle sprung out of true, too small a flange and not relieved, flanges sprung so that they do not come in contact with the wheel at the outer edge, one flange smaller than the other, the tightening nut all battered from setting it up against the flange with hammer and chisel, part of the driving pulley chipped out, only part of the hand rest left, machine on flimsy foundation and no protection hoods. These are a few of the many reasons which cause the breakage of wheels and are conditions that should be eliminated and discouraged by every grinding-wheel salesman. In fact, where such conditions exist manufacturers should refuse to furnish grinding wheels. Many first-class makes of grinding wheels have been condemned on account of breakages which absolutely were not in any way caused by the faulty workmanship or material, but strictly on account of worn out and flimsy grinding stands, together with the rough usage of the wheel. Consequently the grinding-wheel manufacturers must have the co-operation of the wheel users and proper protection and treatment given the grinding wheel to eliminate useless and serious accidents.

It is unwise and bad practice for any grinding-wheel manufacturer to endeavor to convey the impression among users that no danger lies in the use of his particular make of wheels. Where confidence has been established that there is perfect safety in the use of this or that make of wheel less attention is given to safety protection. The grinding wheel is dangerous and great care should be exercised in its use. Safety hoods and other safety devices should be provided.

High explosives are dangerous, yet most necessary. There would be just as much judgement used in trying to educate the users of high explosives that this or that kind of an explosive could be handled in almost any manner without any fear or danger as for the wheel manufacturers to try to convey the impression that grinding wheels of any kind are safe without protection and great care in their use.

To educate the trade that grinding wheels are dangerous to use is not going to lessen the demand for them. They are an absolute necessity the same as high explosives, but they must be handled with care. Whenever a grinding wheel is broken in use, regardless, of the particular makes close investigation of the cause of breakage should be made by the salesman, who in many cases believes that he has profited through the breakage of the competitor's wheel. He must realize that breakages under the same conditions are liable to occur to any make of wheel.

UNFAIR CONSIDERATION.

The manufacturers of files, taps, drills, hacksaws and other shop tools are seldom, if ever, called upon to make replacements in cases of breakages excepting in rare cases where evidence of defects in the manufacture of those tools is shown. They are not, however, immediately condemned on account of breakage, as is most generally the case of the grinding wheel. The fault is usually laid to the carelessness of the operator, but not so with the breakage of the grinding wheel. The operator simply states, "The wheel broke without any apparent cause," and further states that he refuses to work on that particular make of wheel because "it broke," and in most cases he is usually sustained by the powers that be. In all fairness, why should not the operator of the grinding wheel be reprimanded for unjust treatment of the wheel the same as the one who uses other classes of tools in the shop? The mere fact that workmen are not killed or badly injured in the breaking of other classes of shop tools does not alter the principle of the case in the least. The same consideration ought to be given the grinding-wheel manufacturers as is given manufacturers of all the other lines of tools.

INSTALL HIGH GRADE MACHINES.

The highest grade wheel stands possible should be installed. See that flanges are fully one half the diameter of the wheel and recessed, that steel protection hoods are provided and insist that careful treatment be given the wheel. Place the grinding-wheel stand upon a rigid foundation and doubtless no accidents will occur through breakage of the grinding wheel.

When the list of machinery is submitted to the bidder, specifications of the construction of the various machine tools are given, the lathe must have a certain size spindle, swing, distance between centers, depth of bed, ratio of the gearing for power, weight, etc. Practically the same conditions apply to the planing, drilling, milling and shaping machines, etc.

The grinding-wheel stand is usually the last machine on the list of tools specified. It is given the least consideration of any tool in the shop. The specifications for the machine usually read: "Grinder to carry two wheels of certain diameter." Consequently a proposal is entered by the bidder to show the lowest cost possible. In many cases where the question is put to the buyer as to the kind of a grinding machine he would like to purchase he will usually state: "Most any old thing will do, just so it will carry two wheels of a certain diameter." More times he will state, "If you have a second-hand grinding machine, it will do." Buyers of machine tools should, in fact, give greater consideration to the specifications of the grinding stand, owing to the rough usage it receives and the danger in its use, than any other machine tool.

It seems strange, yet true, that where a workman is in danger of getting a finger or hand taken off in slow traveling gears you will usually find guards carefully provided, but where he is very likely to lose his life through the breakage of the grinding wheel, practically no protection is given.

FINISHING BY GRINDING.

In late years what a tremendous advancement has been made, especially in precision grinding. I recall about fifteen years ago the first large cylindrical grinding machine was offered to the trade. When one of the principal inventors of the machine called on the big engine builders in the Middle West, well do I remember how little consideration was given the man who was years ahead of the times, as is proved by the fact that thousands of those very machines are used for the purpose of roughing as well as finishing by grinding the world over at the present time. Three of the most important objections made at that time to the grinding machine were: The belief that the particles of emery would imbed themselves in the work, that the wheel would be reduced anywhere from one eighth to one quarter inch in grinding from one end of the work to the other, and further that the price was entirely too high for a grinding machine. Argument after argument against installing the machine even on trial was brought forth. "No, sir, there was nothing to it." The method of finishing in the lathe with a water tool, a file, an emery cloth fastened to a "slapstick" and oil could not be beaten, but the inventor knew he was right.

Strange to note, where water some years ago was considered most essential for milling and gear cutters, reamers, slitting saws and such fine edge tools, practically no water is used at the present time on these classes of fine edge tools excepting, of course, the larger class of inserted tooth milling cutters and reamers, thus demonstrating the wonderful advancement of the wheel manufacturer to a position to furnish extremely soft, porous and consequently cool cutting wheels. With the proper grain and grade no water need be used in sharpening this class of tools. The use, however, of self-hardening, high-speed tool steel has assisted greatly in this respect.

ROUGHING AND FINISHING WITH THE SAME WHEEL.

Just a few years back, and in many cases even at the present time, the general impression is that to obtain a fine finish it was necessary to use a fine grain wheel. This practice and belief, however, is practically done away with, demonstrating the rapid and improved methods employed by the wheel manufacturers who have educated the users of wheels that the desired finish on a piece of work can be had through the changes of work and wheel speeds, together with the traverse of the grinding-machine bed. In a great majority of cases roughing and finishing can be accomplished with the same wheel through the many change feeds provided on the modern cylindrical grinding machine. By revolving the work slowly, taking a heavy cutting feed and traveling the work longitudinally at high speed, it would naturally leave a coarse finish and consequently reduce stock rapidly, and by advancing the work speed, taking a light cut and slowing up the traverse of the work, a very high finish can be obtained with the same wheel. Often where a satisfactory wheel is furnished to conform to a set feed, the changing of the work speed will change the action of the wheel in such a decided manner as to render it worthless for the work it was intended for. It is also true that many times where a wheel is apparently unsuitable for a certain class of work, through the manipulation of change feeds and wheel speeds, very satisfactory results may be brought about, thoroughly demonstrating that the several changes of feeds placed on the modern cylindrical and other classes of precision grinding machine are placed there for a purpose.

If a wheel does not produce the desired results in conformity to the immediate set of feeds, it should not be condemned before various changes of feeds and wheel speeds are tried out.

Machining manganese steel is commercially an impossibility. Here again the grinding wheel makes one of the greatest steel products of the world a success by playing its most important part in bringing to size all sizes and shapes of manganese castings. Fifteen years ago manganese was practically introduced in the United States for the first time commercially. At the present

*From a paper read at a recent conference of the salesmen of the Abrasive Material Company. Reproduced from *The Iron Age*.

time many hundred tons per day are being cast throughout the United States and being used extensively the world over. It is used in the manufacture of frogs and switches, dredge buckets, safes, heavy driving gears, rolls, etc., where tremendous strength is necessary. Its extreme toughness accounts perhaps for the success of grinding manganese steel, although this toughness will ruin any tool steel in quick time. You will find wherever manganese castings are finished to size, all kinds of machine tools are converted into grinding machines, demonstrating the importance and necessity of the use of the grinding wheel in the finishing of manganese steel.

GRINDING OF CRANK AND CAM SHAFTS.

Perhaps nothing in the field of grinding is of more importance than is the finishing of automobile parts, particularly crank and cam shafts. The crank shaft in many cases is ground from the rough forging, depending upon the particular style of throw. If the clearance of the crank throw is such as to permit the wheel a clear passage to the crank pin the method of grinding from the rough forging is usually employed. However, where it becomes necessary to remove the stock from the sides of the crank throw, it is more economical to rough turn the crank pin in the same set-up and finish by the grinding. The cam shaft in most cases is rough ground from the forging, case hardened and finished with a softer and finer wheel. The use of the grinding wheel for the finishing of all parts of automobiles is beyond description. Internal, cylindrical and surface grinding of all parts of the automobile are thoroughly responsible for the perfection obtained.

One of the most important suggestions to the operator of a crank grinding machine is to make sure that the carrier of the lathe dog is most securely fastened to the work so that there may be no possible chance of the shaft slipping in the carrier. This is mentioned for the reason that very serious accidents have happened through this oversight, as nothing will break a wheel quicker than to have the work slip in the carrier. Cases of this kind have happened and the fault of the breakage laid to the wheel being cracked or defective, no other reason being visible. Another advisable suggestion to prevent accidents of this kind is to keep the work centers of the machine well oiled. Do not let them run dry or the same results are likely to happen as described above without detection of the real cause of breakage.

An increased demand for ring wheels for side surface grinding has been quite noticeable in late years. Several of the prominent manufacturers of disk grinding machines have provided cylindrical chucks to attach to such machines. These previously were considered for use in finishing only, but in recent years have developed wonderfully in the way of roughing as well as finishing. Therefore the ring or cylinder wheel equipment furnished with the disk grinding machine makes a very desirable and indispensable grinding machine, as the work can be roughed down on the ring wheel at one end of the spindle and rapidly brought to size with a high finish through the use of the emery circle mounted on the steel disk at the other end.

The swing frame grinding machine without proper safety appliances is nothing more nor less than a death harness. The operator is obliged to handle the grinding wheel, placing himself between two handlebars. This machine is indispensable on many classes of work, especially large and irregular shapes which cannot be brought to a fixed floor stand. Therefore this type should be given special care in protection against possible wheel breakage. Another dangerous operation for which the swing frame machine is employed is that of grinding grooves in frogs and switches. It requires an experienced operator to travel a grinding wheel back and forth in groove grinding of any kind. The least thrust sideways wedges the wheel in the grooves and usually breaks it. A steel safety hood, protecting the workman from flying pieces, should be installed on every machine. This also applies as well to the flexible shaft machine, which in many cases is used for the same operation or wherever it is impossible to bring the work to the wheel.

THE FUNCTION OF FLANGES.

The flange plays a very important part in the protection and support of the grinding wheel. Opinions differ somewhat as to the diameter of flanges relative to the diameter of the wheel. However, my opinion is that the minumum diameter of flanges should not be less than one half the diameter of the wheel and as much larger as possible consistent with grinding conditions. If possible use more than one set of flanges so that changes can be made as the wheel wears down. Objections are sometimes made against large-diameter flanges on account of interfering with the grinding on the side of the wheel. If it becomes necessary to do any amount of this class of grinding it is advisable to equip the floor machine with a cylinder to carry ring wheels, which are made especially for side grinding, or the cup wheel with a protection hood. However, if the straight wheel is used for this purpose, do not forget that an unusual strain is put on the wheel and the greatest of judgement should be used in this operation. Side grinding on a straight wheel should be discouraged wherever possible and cylinder wheels recommended.

Grinding on the top of the wheel is a very dangerous operation. Many serious accidents have resulted in this method of grinding. If the work is allowed to ride over the wheel to the front it is likely to catch on the wheel and be carried rapidly to the hand-rest. The crash usually results in a broken wheel. While this class of grinding is extremely dangerous and should be discouraged, yet if such method becomes absolutely necessary, the operator should by all means place himself back of the machine so that the wheel will revolve from him rather than toward him as is the case when standing in front of the machine. This would prevent the wheel from at least catching the work and snapping it down to the hand-rest.

Secret Photographs

It is well known that photographs may be rendered temporarily invisible by treatment with potassium ferrocyanide; and in actual practice occasion is found to make use of this fact. The more usual photographic papers, however, coated with chloride or bromide of silver, lend themselves poorly to this business of secret writing or secret pictures. The coating of gelatin or collodion which masks the image betrays its nature at once and, at the least suspicion, nothing is easier than to make the hidden image disappear.

This difficulty may be avoided, says a writer in a recent number of *La Nature*, by using the ordinary commercial sepia paper, obtainable everywhere at a very reasonable price. This paper, when used for the purpose under discussion, offers the great advantage that it is in no way distinguishable from paper of ordinary printing. In fact, it is not specially coated for invisible printing at all, being simply treated with silver nitrate and iron citrate. For this purpose the following solutions should be prepared separately:

(*A*)	Water	50 cc.
	Green ammoniacal iron citrate	20 gr.
	Citric acid	5 gr.
(*B*)	Water	10 cc.
	Silver nitrate	5 gr.

At the moment of use these solutions are mixed, together with enough water to make up a total volume of 100 cubic centimeters, giving a thick liquid which is spread just as it is on the paper. If it seems likely that a single application will not afford a sufficiently strong image, a second coat may be applied after the first has dried. When kept thoroughly dry the paper thus prepared will remain in good condition for several months.

The length of the printing exposure is shorter than in the case of chloride papers. In fact, the printing must be halted as soon as the details begin to be faintly visible. The developing is accomplished very simply, by a mere bath in pure water, which should be renewed several times. The image then rapidly acquires its full intensity; it is of a disagreeable yellow shade, shifting to brown in a 10 minute fixing bath of 3 to 5 per cent solution of hyposulphite of soda. Upon drying, the print then gains strength and takes a handsome sepia tone. It is not very rich in mezzotints; but for the present application this lack is of no consequence.

To make the image invisible, the paper is now immersed in:

(*C*)	Water	1000 cc.
	Copper sulphate	10 gr.
	Potassium bromide	20 gr.
	Hydrochloric acid	5 drops

The image disappears instantaneously. The print should be washed briefly, and allowed to dry. If necessary or convenient the paper thus bleached may be written on. For this purpose India ink diluted with a little gum arabic may be used. This is easily removed, when the time comes, by plain water.

The bleached image will reappear on immersion in any developer whatever, in a bright light. An old bath of hydroquinone, metol, etc., is perfectly satisfactory, and will restore the print in an instant. Fixation is useless, as each point of the surface contains only just so much of the bromide as is strictly necessary and sufficient for its restoration. If occasion arises, the restored print may again be bleached by the bath (*C*), again restored with developer, and so on indefinitely. It is thus possible, our French authority naïvely adds, to have about one "secret papers which can be consulted only when well sheltered from indiscretion."

Protecting Aeroplane Propellers

Metals are generally too heavy to be used for aeroplane propellers, and wood has been found the most desirable material. To protect them, and also to reduce air resistance it is customary to varnish and polish the surfaces, but the varnish soon wears off, and the wood becomes roughened. As a remedy for this it is proposed to coat the wooden propellers with metal by the Shoop metal spraying process, and for this aluminium has been found very effective. Applied by this process the metal clings firmly to the wood, especially if applied before the wood is smoothed, and then the blades can be given a fine and lasting polish.

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